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Contra Accounts

There is a growing tendency in this country to accord orders to firms whose names figure in the sales ledger of the buying firm. It is by no means unusual for a commercial representative to be received with an apologetic statement that a quotation was required just to check so and so's price as this latter firm has to have the order as they are large buyers! The domination of the sales department over the buyer is to be deplored, as the one section is just as important as the other in relation to the ultimate profit ascertainment. So far as general industry is concerned, it often creates much waste, as half a dozen firms may be making an expensive endeavour to obtain business, which is not genuinely available. This does not only apply to plant, but also to running supplies, and we know of cases where a traveller has to call regularly on a firm with a large buying capacity, because, if at any time reciprocal buying ceased, then a chance of large scale business would occur. Contra accounts are so apparent in some cases that travellers might usefully be given a list of articles, such as one receives at the Customs House on arrival at a United Kingdom port, saying that in these cases the firm, owing to the control exercised by the sales department, has closed its market for an indefinite period. It would be much more honest than the excuse that "at the moment" no orders are being placed, but that the name of the salesman and firm will be kept before the buyer for the next occasion they are in the market. Sometimes this phrase is used when it is not a case of "contra account," but of the supply by a subsidiary company. A really bad phase of reciprocal buying is that a large corporation could force the products of a small subsidiary company upon a large number of customers just because of the great buying capacity of the parent concern. We do not assert that this is being done in this country, but it is hinted at by writers in the American Press. It is not only the buyers who are to blame, but the salesmen themselves, who suggest to their own buyers that it would help if they placed a few orders with the Jones & Smith Company, and then promptly use this transaction as a lever to promote their own sales. This restriction of market, which is recognised as being detrimental internationally where pure bartering is often practised, should be suppressed wherever possible. It sometimes arises through lack of confidence in a customer's credit, so rather than miss a sale, goods instead of cash are accepted. Whilst trade is good, the time is opportune to review all contra accounts and to free trading conditions as far as possible from any stigma of bordering on bartering. The flow of actual money is recognised as being good for industry, and the complete suppression of reciprocal trading would make a real contribution towards prosperity. A series of resolutions on the subject by the various Chambers of Commerce might help to set the ball rolling towards a very desirable goal.

Cast Iron in Engineering

Cast iron is the most widely used material in engineering structures. Although it is, or was at one time, a material of comparatively low strength, it nevertheless behaves in service as if it were stronger. What is the reason for this? We suggest that it is to be found in the attention now being given to the importance of plastic distortion. In the usual ductile materials, like wrought iron and mild steel, the ductility, in the ordinary ranges of stress used in engineering work, is almost wholly elastic. The strain disappears if the load be removed. In fact, engineering design is based on the elastic limit not being exceeded in practice, to avoid which the factor of safety is adopted. In the case of cast iron the strain set up when it is stressed is partly elastic and partly plastic, and only the elastic part is recovered when the stress falls, the plastic strain or set remaining as permanent. There is a small plastic strain even at low loads. It is now beginning to be recognised that this plastic strain, far from being harmful as a non-elastic strain, is in fact an advantage, for it is the factor which enables a local concentration of stress, which might otherwise be able to cause damage to the material, to be dissipated and hence rendered harmless. This particularly applies to cases where parts are in motion and under regularly occurring alternating stress, that is, in fatigue. It probably explains why the fatigue values of cast iron are rather higher than would normally be expected. Combined with the graphite cavities, which make the material insensitive to notching as well, we see that there are good reasons for expecting cast iron to behave better than its ordinary static strength indicates. In fact, useful as is the tensile strength for comparative purposes of judging irons and for control and specification use, it entirely fails as a means of enabling irons to be compared with the steels, except in the comparatively few cases where they may be used in direct tension. In most cases engineering materials are under complex and even periodic stresses even at elevated temperatures, of which there is no better example than the automobile crankshaft for which it is proving so successful in practice. The better designing of castings is already receiving attention.

Gun Metal

TREATMENT FOR PRESSURE TIGHTNESS

By FRANCIS G. JENKINS*

Gun metal bronze is still one of the most important of non-ferrous alloys. This is due to a combination of properties such as strength, toughness, good casting characteristics, an excellent resistance to sea water corrosion and erosion and to severe acid conditions.

The zinc bronzes—88 parts copper, 10 parts tin and 2 parts zinc, and 88 parts copper, 8 parts tin and 4 parts zinc—are commonly known as admiralty gun metal in England; government bronze, gun metal and composition "G" in America. A modification of the old well-known 88-10-2 is the increasingly popular alloy 88-8-4 possessing improved physical properties with better machinability.

Three Classes of Gas Porosity

Small round pin holes on the surface collectively, or a large cavity or blowhole with small ones around it in cope or drag after the skin of the casting is removed, are due to gas. Investigators have divided so called gas porosity into three classes: (1) Occluded mould gases including steam, a mechanical fault; (2) Occluded metallic oxides, and (3) Occluded furnace and melting gases including SO_2, CO_2 and CO.

Mould Gases

The mould itself may supply large volumes of gases. Such gases include steam from green-sand, air held in the pores of the sand, carbonic oxides from the ignition of carbonaceous mould facing materials and core compounds, hydrocarbons from the decomposition of organic bonding compounds, and gases from the interstices of chills. Some of the gas may be dissolved but most of it remains insoluble and in the form of distinct bubbles. If the metal is too viscous to allow the gas to escape, then some gas will be retained. This gas will cause blowholes in the resultant casting which will usually be irregularly distributed and often confined to the surface.[22] The prevention of trouble which arises on account of mould gases belongs properly to the study of foundry technique. The moisture content of the sand in the mould should be carefully regulated and sometimes the type of grain as well. Also cores must be well baked and thoroughly vented to permit rapid exodus of the gases.

Metallic Oxides

This condition, consisting for the most part of occluded *tin* oxide, is commonly called oxidation. The presence of tin oxide in zinc bronze is definitely harmful. The fracture has a reddish chocolate appearance and almost always indicates low physical properties and porosity. The mechanism of the latter probably is that metallic oxides in contact with dry-sand cores produce oxides of carbon which are entrapped in the freezing metal around the core causing a ring of holes in the casting. This trouble is encountered more frequently in bronzes of higher lead content.[27] To avoid oxidation, the use of chips and scrap must be prohibited as well as excessive heating and soaking of the melt in the furnace. However, the chief remedy is the proper use of the deoxidising agents zinc and phosphorus.

This alloy may be melted in the usual types of bronze melting furnaces. If ideal quality or the highest mechanical properties are consistently required, melting in crucibles placed in a natural draft pit type furnace is recommended. In the crucible process ingot copper is first melted and protected from oxidation by a covering of crushed charcoal. Although zinc and tin are both fairly good deoxidisers of copper, it is advisable when making up gun metals to deoxidise the copper with zinc. This procedure is followed because zinc oxide readily floats off in the slag while tin oxide if once formed is difficult to remove because of its tendency to ball up and thus escape the reducing action of subsequent additions of zinc or phosphorus.[30] Nickel in the form of 50 per cent. cupro nickel is added together with the zinc; followed, after a proper interval, by the tin while the lead additions, if any, are delayed until just before the crucible is ready to withdraw from the pit. Before pouring, the melt is again deoxidised, this time with phosphorus and vigorously stirred with a graphite rod. Phosphorus is usually added as a copper phosphorus alloy containing 10 to 15 per cent. phosphorus in which it exists as the compound Cu_3P.

Furnace and Melting Gases

Another type of gases is dissolved or combined with the bronze. They originate either in the raw metal used for preparing the alloy or are picked up from the furnace atmosphere during melting. Excessive heating or soaking of the metal will serve to aggravate the condition.

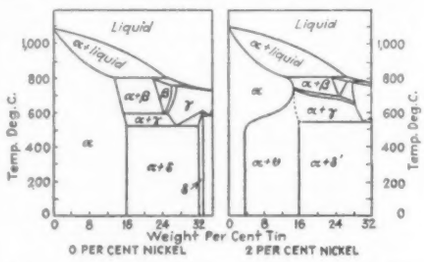

FIG. 1.—EQUILIBRIUM DIAGRAMS FOR GUN-METAL AND GUNMETAL WITH 2 PER CENT. OF NICKEL.

It has been fairly clearly established that dissolved or occluded gases are more soluble in the molten than in the solid metal and that in both the solid and liquid the solubility falls with the temperature. The result is that during the cooling of a casting gases are likely to be liberated. Some of this gas will have the opportunity to escape through the liquid metal and free itself from the casting entirely, but if the volume of liberated gas is large or if the molten metal is viscous some of this gas, like mould gases, may remain entangled in the metal and appear in the castings as blow holes. Gas may be also liberated during the actual solidification of the metal.[32]

There appears to be a critical rate of cooling for a given bronze above which the gases are not liberated, and by controlling the casting temperature (keep below 1,260 deg. C.) or by casting in chill moulds so that cooling is sufficiently rapid, sound castings free from gas bubbles may be normally obtained.[22]

Also there is plenty of evidence that it is best to melt bronze in a slightly oxidising atmosphere if unsound castings are to be avoided.[16 21] The reason might be that it is not likely that the blow holes are formed by the liberation of oxygen, as the oxygen present in the metal is readily removed by the formation of metallic oxides. These oxides are in turn eliminated by use of the deoxidisers zinc and phosphorus. However, investigations show that a furnace atmosphere high in carbon monoxide, an essentially reducing atmosphere, has a most deleterious effect on the soundness.

This covers in a brief way the chief causes and remedies of gas porosity. One last caution—it should be remembered that in general, if the metal be poured too cold, it will be too sluggish and viscous to liberate any gases involved.

Intercrystalline Shrinkage Porosity

H. S. Primrose[3] concluded in 1910 that *soundness*, ultimate strength and degree of elongation depend upon the rate of solidification. This is still the opinion to-day,[18 33] when it is maintained that the fundamental cause of shrinkage porosity is slow or prolonged freezing with consequent sluggish feeding of sections. The reason for the difficulty encountered in avoiding such conditions in gun metal is, primarily, its extremely wide freezing range of approximately 195 deg. C. (see Fig. 1).

The equilibrium diagram is of the solid solubility type and inasmuch as metallic solid solutions do not usually crystallise from a single centre outward uniformly but grow in certain directions faster than in others, tree-like forms result known as dendrites. Since during the freezing process bronze contracts considerably, each dendrite occupies less volume than the liquid from which it is formed and consequently tends to leave a space around it. While any liquid metal is available it will flow into these spaces and make good the solidification contraction. If for any reason liquid metal is not available during the whole time of freezing then contraction cavities will be found in the resultant castings. It can be appreciated that, if the freezing covers a wide cooling range of temperature, then a considerable depth of metal from the cooling face of the casting will be freezing at the same time and the feeding liquid will have to traverse a long and tortuous maze of dendrites to fill up the last cavities.[23 34]

Gases may also be liberated during the actual solidification of the metal and play a part in causing intercrystalline porosity. According to Bolton and Weigand[21] the gas rejected in the crystal interstices during crystallisation prevents feed back of the metal—causes shrinkage by preventing feed through back pressure. Most of the controversies concerning gas effects centre around this type of reaction. Dews[22] stated that the cavities are formed primarily by contraction and while they may provide lodging places for liberated gases and may even be propagated by accumulated gases, they are not formed through any buffer action of the gases. In any event it is generally agreed that melting under a reducing atmosphere will aggravate intercrystalline shrinkage porosity even if it does not cause it. Further than this however the porosity may be treated very readily without considering gas liberations at all.

The unfavourable effect of the long freezing range of gun metal on the rate of solidification may be countered. Suitable design and careful foundry practice, including proper casting temperatures and a judicious choice of alloying elements, will increase the freezing rate and produce pressure-tight castings.

Casting Temperature

The casting temperature has, through its influence on the rate of solidification, a greater effect on the soundness of zinc bronze than any one other factor. This was first shown by Karr and Rawdon[6] and subsequently confirmed by Carpenter and Elam.[5] It is obvious that freezing will proceed faster with a low than with a high casting temperature which heats thoroughly the surrounding mould compelling slow cooling. Consequently, providing other factors are kept constant, the density of bronze increases and the grain size will be reduced as the casting temperature falls.

It is on the other hand equally detrimental to cast too low. The poor physical properties that accompany the very low casting tempera-

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tures are not however attributable to structural so much as to mechanical defects. This is due to the increased viscosity of the metal manifested in the form of entrapped oxide and gas and improper feeding.[11] An exact temperature is not easily obtained as procedures and compositions vary from one foundry to another. Following on this to get the same quality in all castings the metal for large and thick castings should not be so highly heated when cast as that which is used for much thinner work. The moulds should be arranged so that light castings are made first with hot metal.

The temperatures recommended[6 8 23] for pouring 88-8-4 fall in the range 1,065 to 1,215 deg. C. and under no circumstances exceed 1,260 deg. C. The temperature should always be determined before the bronze is poured in order to be certain that it is within the safety range. This involves the use of a pyrometer (portable millivoltmeter is most suitable) which can be depended on to give reliable readings. To overcome the effect of the naturally wide freezing range of gun metal, advantage must be taken of the counteracting effect of these low casting temperatures.

Design and Foundry Manipulation

The surface of a gun metal casting, chilled by the mould, is fine equiaxed grained and pressure tight. It is necessary to retain this surface as it offers another legitimate means of circumventing the alloy's liability to shrinkage porosity. The design therefore should maintain a cast finish for pressure castings when possible and a minimum allowance for machine finish when machining is necessary. The avoidance of right angle bends and the coring of heavy bosses are details of design which aid materially in the production of pressure castings. Incidentally, apart from the finely divided porosities produced by the gradual closing of connecting channels, there are the large cavities or so called foundry shrinkage which are to a great extent caused by incorrect construction of the moulds and incorrect spacing of heavy and light sections. The ideal casting should be of uniform thickness throughout while ample fillets should always be provided when it is necessary to run heavy sections into light. A study of the foundry problems involved in the manufacture of pressure castings, especially those of intricate design should begin on the drawing board.

Accurate cores and moulding and well-designed exact pattern equipment, are of major importance for this type of work to maintain the features studied in design, as incorrect shrinkage allowance, excessive machine finish or inaccurately fitting cores may defeat the very object sought in the original design. Selection of the type and size of gates should be given serious consideration in order to permit the entrance of metal to the mould with the least amount of agitation and to distribute metal as far as possible to permit uniform rate of cooling in various sections.

Chilling of heavy bosses may be necessary so as to aid in securing a uniform rate of cooling. In some instances it is advisable to eliminate risers which would normally be used on non-pressure castings and to resort to chills. The riser not only keeps that section of the casting liquid for a longer period, thus increasing its grain size, but its subsequent removal also destroys the skin effect. Where it is impossible to avoid a certain amount of heavy machining, chilling may be employed to augment the dense metal at the surface. Too much emphasis cannot be placed upon the importance of proper machine finish allowance.[24]

The Effect of Alloying Elements

Addition of alloying elements, even in comparatively small quantities, will modify the freezing range in one or the other direction or otherwise change the rate of cooling. The importance of this cannot be too highly stressed for very often a proper composition alone means the difference between a sound and a porous casting. The range of elements that best temper zinc bronzes' wide freezing range is similar to the range for gun metal recommended by Fawcett.[21]

Desired :

Cu	Sn	Zn	Ni	Pb
88	8	4	0.75	0.30

Permissible :

Cu ..	87 to 89	Ni ..	0.75 max.	S ..	0.05 max.
Sn ..	9.5 to 10.5	Pb ..	0.30 max.	Si ..	0.02 max.
or	7.5 to 8.5	Sb ..	0.25 max.	Al ..	None
Zn ..	1.5 to 2.5	Fe ..	0.10 max.	—	—
or	3.5 to 4.5	P ..	0.05 max.	—	—

Nickel especially, zinc and lead when used discreetly, will increase the density and soundness. Within limits, tin, iron, antimony, and sulphur have no appreciable effect. However, the presence of aluminium and silicon must be absolutely prohibited. The tin content is regulated by the physical and corrosion resisting requirements of the alloy, while the iron, antimony and sulphur are present only as impurities.

Nickel.—Small amounts of nickel exert the greatest influence upon the structure of gun metal. They produce a fine-grain, higher strength casting, with dense and steam tight structure,

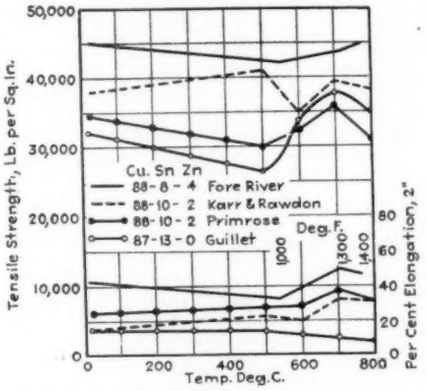

FIG. 2.—ANNEALING TEMPERATURE PLOTTED AGAINST PHYSICAL PROPERTIES.

which is naturally more resistant to corrosion and erosion than a bronze with a coarser structure. The addition of nickel in amounts from 0.5 to 1.5 per cent. will increase the density, although special attention to deoxidation appears to become necessary if the nickel content exceeds this. While the resistance of 88-8-4 to comparatively slight degrees of deformation as indicated by proportional limit and yield point, increases continuously with a rise in nickel content up to at least 5 per cent., breaking strength and elongation reach their best proportions at about 1.5 per cent. nickel content.[22] This quickening of the rate of cooling and subsequent increase in density and strength on addition of small percentages of nickel is all accomplished by some peculiar unexplained property of the element and notwithstanding an uncertain effect on the freezing range.

Nickel quite generally raises the melting point of bronzes. A recent laboratory study shows the increase in liquidus temperature to be about 6.5 deg. C. per 1 per cent. nickel content if nickel replaces copper or 16 deg. C. per 1 per cent. if nickel replaces tin.[25] However, the results of Pilling and Kihlgren[29] indicate it raises the solidus at just about the same rate that it raises the liquidus with little or no effect on the freezing range. Nickel has also been found to increase the fluidity of bronzes, and therefore the raising of the freezing range does not affect the pouring temperature. Providing other factors are correct there should be no necessity for looking to a greater content than 0.75 per cent. to produce a sound close-grained casting. This amount will also produce a uniform distribution of lead.

On the addition of nickel to gun metal, a change also takes place in the copper-tin alpha phase boundary and the alloy is rendered age hardenable.

Zinc.—Zinc exerts no effect on the freezing range but is of importance, as it increases the fluidity of the metal and facilitates casting at low temperatures. It also acts as a deoxidiser upon any oxide of copper present. The excess zinc goes into solution and has the same effect upon the constitution as the addition of tin. Guillet[2] determined experimentally that tin has a coefficient of equivalence of two with respect to zinc as unity.

Lead.—The chief effect of the presence of lead is mechanical. It improves the machinability and will also prevent checks or cracks at the junction of a boss and the body of the casting. In a case of this kind it would aid in pressure tightness. Furthermore, that portion of the alloy containing lead is the last to solidify, and therefore aids in filling the crevices caused by the internal shrinkage. The amount necessary to bring out the best machining qualities with a minimum loss in physical properties is only 0.50 per cent.[31] This figure is often lowered to 0.30 per cent. to prevent pyramiding of scrap. In general, lead detracts from strength and hardness because of the facility with which fracture passes through these globules.

Antimony.—There is apparently no effect on the soundness of sand-cast gun metal containing up to 1.5 per cent. of this impurity, though there is reported an increase in hardness and tensile strength.[9 10]

Phosphorus.—Phosphorus content should be kept low because of its tendency to increase the freezing range by depressing the temperatures at which freezing is completed without a proportional lowering of the temperature at which freezing commences.[32 31] It is common practice to add a little phosphorus to gun metal for the purpose of deoxidising the metal. Additions of less than 0.05 per cent. are rarely harmful, but do little good unless they represent a distinct excess after reduction of oxides has been accomplished.[23] Above 0.05 per cent. causes the appearance of the free Cu_3P and a reduction in the mechanical properties.

TABLE I.—*Summary of Experiments on Heat-Treatment.*

Composition : 88-8-4.			Average of three specimens (0.505-in. bars).		
	As-Cast.	Annealed 538 deg. C. 2 hrs.	Annealed 705 deg. C. 2 hrs.	Annealed 760 deg. C. 2 hrs.	Quenched 705 deg. C. 2 hrs.
Max. load, tons per sq. in. ..	20	18.5	19	19.5	20.5
Elong. (2 in.), per cent. ..	42	32	50	46	62
R.A. (approx.), per cent. ..	40	34	40	42	44
Dendritic structure	Medium mesh	Some diffusion	Disappeared except for faint shadows	Disappeared	Disappeared except for faint shadows

Silicon.—Silicon apparently goes into solution and alters markedly the crystallisation characteristics. Very small percentages in bronzes containing copper, tin, zinc, and lead have a tendency to produce a coarse dendritic structure with intercrystalline fissures which cause castings to be weak and porous. Bolton and Weigand[21] found that 0.02 per cent. silicon was not dangerous though 0.04 per cent. was very.

Aluminium.—The presence of aluminium should be carefully guarded against for, in a manner similar to silicon, it alters crystallisa-

tion. Aluminium increases the grain size and is the cause for a high percentage of leakers, especially in castings of thin section.[21] It does its greatest damage when added to alloys containing lead.

Annealing for Pressure Tightness

It may so happen that the design or the foundry practice was not quite as it should be or a particularly difficult and intricate part is encountered and a porous casting results. This fact is not discovered, however, until the machining has been entirely completed and the piece has been subjected to hydrostatic pressure. Rather than lose the money spent on machining and casting and risk a recast which in turn might be equally as bad, the piece may be made sound by annealing (heating to just below the solidus). This refers, of course, only to castings afflicted with intercrystalline shrinkage porosity.

Besides closing the shrinkage pores, annealing will relieve casting strains[15] and effect diffusion of the as-cast dendritic structure. In its annealed state the microscopic examination shows the metal to have been completely crystallised into the characteristic polyhedral crystals of alpha bronze. To the non-ferrous metallurgist a homogeneous solid solution, such as is produced by annealing, indicates properties far superior to a dendritic structure. The elongation and reduction of area are substantially raised though the strength, yield point and hardness are affected but little. The improvement in the physical properties and the relief of internal stress alone, capable of being brought about by annealing, has not resulted in the process being brought into standard industrial use.

Several reasons might be given for this, the chief being that, by proper control of process and materials, a satisfactory margin over specifications could always be obtained without recourse to annealing. There was also the fear, though not warranted, that treatment at a temperature of about 700 deg. C., would cause large castings to sag.

H. S. and J. S. G. Primrose,[4] referring to 88-10-2 (see Fig. 2), concluded that annealing of the metal for 30 min. increases very considerably its strength and elongation, the most satisfactory results being at 700 deg. C. The homogeneity and other physical properties of the metal are correspondingly improved, but particularly the ability of the castings to withstand hydraulic pressure. Some additional experiments by H. S. Primrose[5] confirmed the fact that only an almost inappreciable change in structure was produced by any annealing conducted at a temperature much below 700 deg. C. Karr and Rawdon[6 7] studied the alloy 88-10-2 in great detail and found that heat treatment is productive of increased ductility and tensile strength when annealed in the range 700 to 800 deg. C., which is in accord with the results of Primrose. Comstock further verified Primroses' conclusions that annealing at about 700 deg. C. is beneficial.[12]

The results of experiments conducted with the alloy 88-8-4 (see Fig. 2, Table I) agree quite well, as would be expected with the previous work on the slightly different alloy 88-10-2. It was found that an anneal in the range 700 to 787 deg. C. will give pressure tightness with a perceptible increase in ductility over the as-cast and a definite increase in physical properties over an anneal at 535 deg. C. Diffusion will take place only very slowly, and in consequence prolonged periods of annealing are necessary. In the case of large sand castings, the removal of dendrites is not technically practicable. The treatment therefore necessary to obtain the best results is determined by the size and condition of the casting. The recommended practice is one hour for each linear inch of wall thickness at 760 deg. C., though the heating may be for a shorter time at a higher temperature or for a longer time at a lower temperature.

It is evident that such treatment tends to protect from hydraulic failure porous castings suffering from intercrystalline shrinkage unsoundness by closing the grain and lessening the interstices or voids between the crystals. Though the mass is compacted to an extent which renders it pressure tight, the actual mechanism is obscure. This closing of microscopic pores may be the result of the dynamic equilibrium of the molecules and their constant effort to adjust themselves, one to another, to assume the form of greatest physical stability. The atoms in a crystal lattice are in a state of thermal vibration around their average positions at all temperatures above the absolute zero—the higher the temperature, the greater the amplitude and the higher the frequency of the vibrations. Still another opinion advanced is that the voids might be closed through an increase in volume of the matrix taking place concurrently with the absorption of the dendritic structure. That is, the homogenised structure may occupy greater volume than the cast structure.

Rapid Cooling Following Annealing

Karr and Rawdon[6 7] found that in quenched bars of 88-10-2 superior results, slightly better than the annealed, were obtained in the temperature range from 600 to 700 deg. C. C. F. Smart[13] studied the effect of annealing 88-10-2 followed by different rates of cooling and in particular the effect of quenching. He recommended, whenever possible, a quench followed by an anneal at a lower temperature to draw the strain out of the casting and maintained furthermore that air cooling gave better results than furnace cooling. The cause of the improvement attained by rapid cooling was first suggested by Price, Grant and Phillips[19] and later elaborated by Pilling and Kihlgren.[28 29] They explained that nickel causes a change to take place in the solubility curve, and although the solubility at higher temperatures is little altered, that at lower temperatures is lowered, see Fig. 1. Thus the bronze may by suitable heat treatment be age hardened, due to the precipitation of a dispersed constituent. The heat treatment consists usually of annealing and quenching from about 760 deg. C.; although air cooling will suffice for small castings followed by tempering at about 315 deg. C. There is also the possibility that an iron-rich compound would be precipitated by a 760 deg. C. heat treatment.

Nickel is completely miscible in alpha-range copper-zinc alloys even to the complete replacement of the copper content by nickel. That is to say, the presence of nickel leads to the development of no new constituent and the zinc content marking the first appearance of the beta phase is but scarcely changed by the presence of even 20 or 30 per cent. of nickel.[26]

On the other hand, the alpha range of the copper-tin alloys is sharply restricted by nickel. If the tin exceeds that of the alpha boundary, insoluble nuclei are formed and an excess phase is precipitated. The solubility of tin in the alpha phase of the copper-tin system decreases between 590 and 500 deg. C. and then remains constant to room temperature. The solubility of tin in the alpha phase starts to decrease at the nickel content at which the alpha comes in equilibrium with the theta phase, which varies between about 0.5 and 3.5 per cent. nickel.

The precipitated phase has been designated as theta. The theta constituent is clear, and has a blue colour on etching with acid ferric chloride. It has a nodular and needle-like form and, while most of it occurs in the alpha, some of it also locates at the grain boundaries. The theta phase is thought to be either the compound Ni_4Sn or Ni_3Sn of the nickel-tin system reported by Voss or, what is more probable, one of those compounds containing copper in solid solution.

The microstructure depends upon the rate of cooling through the temperature range in which the solubility of tin decreases in the alpha range. When an alloy is cooled fairly rapidly through this temperature range, the theta constituent is precipitated in a very finely divided state in the alpha. After etching this mixture has a dark appearance. When these alloys are cooled at a much slower rate, the theta phase coalesces into large grains and the alpha matrix is clear after etching.[32]

Experiments conducted with 88-8-4 (see Table I) indicate that the physical properties of the annealed bronze are improved by quenching, though not markedly. This is explained by the small quantity of hardening elements present, including a maximum nickel content of only 0.75 per cent. Attention is directed to the excellent ductility associated with high tensile strength and proportional limit.

There is, however, considerable danger from cracking, in quenching castings, especially if the castings are large; not as much from the effect of the quenching medium as from the handling of heavy sections. It is obvious, however, that if, following an anneal, a quench is not practical, an air cool or even the mere opening of the furnace door would be beneficial.[13]

(*Concluded on page* 480.)

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Institute of British Foundrymen

ANNUAL DINNER OF THE LONDON BRANCH

MR. V. DELPORT (President of the London Branch of the Institute of British Foundrymen) presided over a jolly gathering of members and their guests on the occasion of the annual dinner of the Branch, held at the Charing Cross Hotel, London, W.C.2, last Friday. The company included Mr. W. Christopher (Master of the Worshipful Company of Founders), Mr. Hatswell (a Past Master of the Worshipful Company of Founders), Baillie H. Winterton (President of the Institute), Mr. G. T. Lunt (President of the Foundry Trades' Equipment and Supplies Association), Mr. Barrington Hooper (managing director, FOUNDRY TRADE JOURNAL), Dr. H. J. Gough, M.B.E., D.Sc., F.R.S. (chairman of the London Section of the Institute of Metals), Mr. K. Headlam-Morley (secretary of the Iron and Steel Institute), Mr. S. C. E. Lloyd (Stewarts and Lloyds, Limited), Mr. K. W. Bridges (F. W. Bridges & Company, Limited, who organise the foundry exhibitions), Mr. J. E. Hurst and Mr. V. C. Faulkner (Past Presidents of the Institute), Mr. F. O. Blackwell (immediate Past-President of the Branch), Mr. C. C. Booth, J.P. (Vice-President of the Branch), Mr. W. B. Lake, J.P. (hon. treasurer of the Institute and Past-President of the Branch), Mr. J. W. Gardom, Mr. H. O. Slater and Mr. C. H. Kain (Past-Presidents of the Branch), and Mr. H. W. Lockwood (hon. secretary of the Branch).

A message of good wishes was sent to Dr. A. B. Everest, the Senior Vice-President of the Branch, who was unable to attend owing to illness.

The Toasts

The loyal toast having been honoured, MR. W. CHRISTOPHER (Master of the Worshipful Company of Founders) very appropriately proposed the toast of the Branch, in a speech which, though brief, was none the less sincere. He spoke with admiration of the processes he had witnessed in the works of John Brown, Limited, of Sheffield, including the withdrawal of an armour plate from the furnace, when the scene was reminiscent of one of Rembrandt's delightful studies of light and shade, and said how greatly he had been impressed and inspired by the manner in which the men had handled that enormous glowing piece of steel, had placed it on the track and had pressed it, all without mishap. Operations at Woolwich Arsenal and at the works of Dorman, Long & Company, Limited, of Middlesbrough, had also impressed and inspired him. Incidentally, that reference reminded him of a happy occasion, in connection with the silver wedding festivities of the late Sir Charles Dorman and Lady Dorman, at Middlesbrough, when he had provided for some 11,000 founders and their friends a temporary inside lining! If, he said, those guests had been as pleased with the operation as he had been to perform it, the assembly was indeed a happy one.

The association between the Worshipful Company and the Institute, he continued, linked the old and the young, for whereas the Company had represented the industry in the middle ages, the Institute represented the trade and the industry in these modern times. He was happy to carry to the Institute the Company's message of sincere goodwill and regard, and said that the Company was always interested to hear of the Institute's progress, and hoped that it might share in the pleasure of the Institute's success. He wished prosperity to the industry and to the London Branch and its parent Institute.

The History of the Worshipful Company of Ironfounders

The BRANCH-PRESIDENT, in his response, first voiced the pleasure which all members of the Branch derived from their first contact with the Worshipful Company. Appreciating that they were all interested to know more of the Worshipful Company, he submitted some interesting and amusing information he had derived recently from the Clerk of the Company. As early as 1210, he was informed, a Mystery of Founders existed, with Masters elected and sworn in to govern it. That was evident from the existence of a Petition in Norman French at the Guildhall, from "the good men of the Mystery of Founders of the City of London," praying for a grant of Ordinances for the regulation of the craft. Their jurisdiction had extended over the manufacture of candlesticks, buckles, spurs, stirrups, straps, lavers, pots, ewers and basins. In 1472 there seemed to have been some kind of reconstruction of the Guild; an old document mentioned, incidentally, that "We began in the year 1472 with 24 poor honest men." That had doubtless marked the transition of the original Guild to some more settled form of incorporation. The Ordinances of 1489 contained directions as to masses, burials, alms, etc. The carrying of wares to fairs, hawking them, restricting the workmanship to members of the craft, alms paid to members, funerals of members (there was a hearse cloth for common use, which was destroyed during the Commonwealth as Popish), and apprenticeship seemed to have been matters which had principally occupied the attention of the Guild at that period. The control of apprentices seemed always to have been a difficult task. They had loved riots and sport, and one of the Ordinances of 1608 had prohibited the playing of bowls, betting at cards, dice-tables and shovel-board. In 1581 the Company had bought the site of their old hall in Founders' Court, Lothbury, which site still remained their most valuable possession. A grant of Arms was made to them in 1590—a Ewer with two Candlesticks, with the motto "God the only Founder." The second Charter was granted in 1614 by James I, giving to the Company its present constitution and privileges. One of the principal duties was the approving and sizing of all brass weights within the City, which were ordered to be brought to Founders' Hall and there "sized and made lawful and good according to our standard in England," then marked with the common mark of the Mystery, "being the form of a ewer," the Company taking the ancient allowance for sizing. That was a very important public trust. Lothbury was then the centre of the trade of the Founders, around the church of St. Margaret, in one of the chapels of which (St. Clement) was placed their common chest, wherein also they performed their religious offices.

For a long period of its existence, it appeared, the wealth of the Company was not great. Their hall was burned down in 1660 and was re-built by voluntary contributions. They were still very poor. Many poor men belonged to the Company, and they made use of it as a Benefit Society. In 1846 the finances of the Company began to improve. They had let their old hall in Lothbury and had purchased a new home in St. Swithin's Lane, where now stands the new Founders' Hall. A large number of members were enrolled as Liverymen. The income of the Company in 1845 was only £100.

During the Commonwealth the Company seemed to have been tainted with political views, and it had been stated that the "Assistants were notoriously disaffected and had manifested their malignity in words and deeds, and had countenanced their Clerk, who was a mocker and a scoffer of all manner of godliness and holiness."

In view of those circumstances, it was not surprising that Founders' Hall, which rose on the site occupied by the original hall, had become a rallying place for people with advanced views on religion and politics. Citizens with the strictly conservative outlook so common within the square mile had actually referred to the hall as "The Cauldron of Sedition." The hall of the Company at 13, St. Swithin's Lane, was acquired in 1854. Whilst some of the ancient Livery Companies had passed their zenith, the Founders' might be said to have entered upon a new lease of life; this latter fact Mr. Delport emphasised.

The London Branch

The history of the Institute of British Foundrymen, he continued, did not extend back to the Middle Ages; but the Institute had acquired great strength in the 32 years of its existence, especially since it was incorporated by Royal Charter, in 1921.

Dealing specifically with the London Branch, he said that on April 30 it had 281 members, and in that respect it came immediately after the Lancashire and Scottish branches; the membership of those two latter branches was not surprising, in view of the extent of the industry in those localities. Actually, however, the membership of the London Branch comprised about 15 per cent. of the whole membership of the Institute, there being 10 branches. The membership of the London Branch at the present time was about 300.

It was also of interest that the London Branch had among its members two living Past-Presidents of the Institute, and that the office of hon. treasurer of the Institute had been held during the past few years, and was still held, by a highly respected member of the Branch, Mr. W. B. Lake, J.P.

There was every reason to be proud of membership of the London Branch, which carried its full weight in the activities of the Institute, thanks to its membership and to the work of those members who were serving on the various committees, etc. The occasion was fitting, he continued, to express thanks to those members who gave so much of their time and thought to the work of the Institute and its various committees, etc. Not only did they give their time and thought to such work, but in the course of the year they travelled throughout the country, which imposed a certain financial burden upon them. Happily, in many cases those members were assisted by their firms in that respect, and thanks were due to those firms for contributing very materially in perhaps an indirect way to the advancement of the aims of the Institute. In that connection Mr. Delport took the opportunity to express his personal thanks to his own firm, the Penton Publishing Company, for the manner in which they had helped him to fulfil the duties with which the Branch had entrusted him.

To those members who had not yet had the opportunity to render active service to the Institute he pointed out that they could help in more ways than one. They could help by attending meetings and taking part in discussions, by introducing new members and by paying subscriptions at the time those subscriptions were due. Although the attendance at Branch meetings had been satisfactory for some time past, there was still room for improvement. Also, by exchanging knowledge and experience in the course of discussion they fulfilled one of the aims of the Institute, which was to spread knowledge among the members generally. He emphasised also that every member increased the Institute's income, and thus the Institute was able to do more for its members; they could only get from it what they were able to put into it. Further, if any members wished to make little gifts to the Branch, those gifts would always be welcomed—a remark which was prompted by the fact that several members had made gifts during the course of the year; to them he expressed the thanks of the Branch. The benefits of the Institute were not necessarily confined to the individual, but to the industry

generally. Thus, by joining, the members contributed to the benefit of their industry, and eventually derived benefit individually.

Mr. Delport took the opportunity to express his personal thanks and the thanks of the Branch to the members of the Branch Council and to Mr. H. W. Lockwood (the Branch hon. secretary), whose enthusiasm rendered his work so very efficient.

At a time when a cloud of madness seemed to be spreading over the world, our own country appeared to be one of the few havens of peace, and it was right that we should enjoy to the full that privileged position. But we should also realise that certain diseases spread, and that the best way in which to combat that madness was for sane men to get together. One of the objects, or perhaps *the* object, of the Institute, in its limited field within the foundry industry, was to get the sane men together and to keep them together. That was the thought he wished to impress upon all.

Finally, he expressed thanks to Mr. Winterton for having travelled from Glasgow to attend the dinner, and respectfully offered best wishes to Mrs. Winterton.

MR. C. C. BOOTH, J.P. (Vice-President of the Branch), who proposed a toast to the guests, extended to all of them a hearty welcome; he mentioned particularly and commented upon the work of Mr. Christopher, Mr. Winterton, Mr. Headlam-Morley, Dr. Gough, Mr. Lunt, Mr. Barrington Hooper, Mr. Hatswell, Mr. S. C. E. Lloyd, and Dr. Wiederholz, of Germany. The reference to Dr. Wiederholz led Mr. Booth to recall with gratitude the very hearty welcome accorded British foundrymen by their fellow foundrymen in Germany when they had visited that country in the autumn.

Written Questions

MR. H. WINTERTON (President of the Institute) responded to the toast. Discussing a reference made previously by Mr. Delport to the importance of overcoming shyness and diffidence at meetings within the Institute, Mr. Winterton said it was pleasing to note that, by dint of considerable persuasion, the foundryman working on the floor, also his foreman and his manager, had become less diffident than they were some years ago, when the interchange of ideas was scarcely ever thought of and very seldom practiced. He mentioned, however, an interesting experiment instituted recently by the Scottish Branch with a view to overcoming the diffidence of many members. Suggestions or questions could be written on paper, with or without the names of the members who made the suggestions or asked the questions, and the result was quite definitely that some of the younger members were having "the infernal cheek" to question the decisions of their elders! That was a good thing, and it had certainly added to the interest of discussions; although some of the questions might be somewhat irrevelant, the older members were perfectly willing to respond and to impart the information which years of practical experience had given them. By that means the general interest in the Institute would be enlarged, and the President commended the practice to other Branches if they had not already adopted it.

The President added to the words of welcome extended to Dr. Wiederholz, and said that the foundrymen who had visited the exhibition at Düsseldorf in September could not have been received more heartily than they were by their German friends.

The London Branch must regard with satisfaction the fact that it had within its membership a greater number of full members than any other Branch of the Institute. In 1921, when Mr. Faulkner had become hon. secretary of the Branch, there was a revivification; from that time the Branch had made very definite progress, and the Branch had very great power in the consultations of the General Council of the Institute. He said he had always been very much in favour of employers and managers being members of the Institute, but when studying the membership he had found that there were not so many foremen and moulders within the membership, and he suggested that the London Branch might consider that matter. Such men might be urged to take great interest in the Institute, because it was for their ultimate benefit that the Institute was formed. He would be very pleased to know that during his term of office more of the members of the craft, and junior members of the craft, had joined the Institute and had become actively insistent upon the improvement of their general position from the working point of view. The Institute was formed to instruct from the practical and technical points of view, and if all Branches kept that matter in the forefront there would be a larger membership for whose benefit the Institute would continue to work day by day.

The International Conference, 1939

The London Branch was rightly proud of the fact that many of its members travelled long distances to attend the Branch meetings; they travelled from places as far apart as Peterborough, Dunstable, Braintree and Luton. There had been six or seven foundry conferences in London; during the war years there were several. In 1926 there was a most successful conference, and in 1929 there was one of the most successful international conferences organised by the foundry trade. Those attending had been welcomed at the Guildhall, and the Institute had received the recognition due to a body of such a character. He looked forward to the international conference to be held in 1939, which he hoped would be attended by many hundreds of foundrymen. It would be held under the presidency of the Institute's present honorary treasurer (Mr. Lake), who had rendered yeoman service for many years; it was hoped that he would be able to render further yeoman service for many more years to come.

The PRESIDENT congratulated the Branch upon its officers—Mr. Delport (President), Dr. Everest and Mr. Booth (Vice-Presidents) and Mr. Lockwood (hon. secretary)—and also upon the formation of the section at Ipswich, which he would have great pleasure in visiting. He expressed thanks on behalf of himself and his fellow guests for the hospitality extended to them.

New Research Announced

DR. H. J. GOUGH, M.B.E., D.Sc., F.R.S. (chairman of the London Section of the Institute of Metals), also responded to the toast, and expressed the thanks of the guests for the gracious welcome and hospitality extended to them. Speaking as one who had been trained as an engineer and who had served an engineering apprenticeship, but had since "degenerated" into research in engineering, Dr. Gough said he was reminded, by the presence of the Master and a Past-Master of the Worshipful Company of Founders, of the profound influence which some of the great City Companies exerted by their contributions to education and research. He hoped that the Worshipful Company of Founders contributed substantially to the Institute's work by way of gifts for education and research.

The close association between the Iron and Steel Institute and the Institute of British Foundrymen, he continued, was evidenced by the presence of Mr. Headlam-Morley, who exercised a great influence on both Institutes as well as other bodies. The Institute of British Foundrymen was to be congratulated upon its President, Mr. Winterton, and upon the help afforded by the technical Press, in which Mr. Barrington Hooper played so great a part. Dr. Gough conveyed the greetings of his fellow members of the London Section of the Institute of Metals, and expressed their appreciation of the close relationship which had existed between them and the London Branch of the Institute of British Foundrymen for so many years, evidence of which was to be found in the joint meetings which were held at least once each session.

As one deeply interested in research and industrial progress, Dr. Gough was very much impressed by the future possibilities for the new cast irons. For more than a quarter of a century, he said, the steelmakers had taken full advantage of heat-treatment and alloying, and had produced a marvellous series of metals for use by engineers, in the air, on the sea or on land. During the last few years, however, some of the members of the Institute of British Foundrymen, and particularly the British Cast Iron Research Association (which was closely associated with the Institute) had applied alloying and heat-treatment to cast irons, and he felt that there would be just as great a use for such cast materials as there had been for steels. He instanced the application of the cast crankshaft, and said that there was a good deal of work now in the experimental stage in addition to that which was being done in production. In a short time there would be announced a scheme, in which the Institution of Mechanical Engineers and the British Cast Iron Research Association were associated, for a very big research, on both the laboratory and the service scale, on high-duty cast irons for general engineering purposes. If that were as successful as he believed it would be, there was a bigger future for foundrymen than perhaps they would have dreamed of four or five years ago.

The company then heard the broadcast of the Duke of Windsor's farewell speech, after which a short concert was given by Miss Eunice Sullivan, Mr. H. A. Fox (a member of the London Branch) and a comedian.

Publications Received

Catalogues of the City of Leeds Public Libraries; Commercial and Technical Library Bulletin. Published monthly dealing with a specific phase of specialised activity.

This service of issuing monthly bulletins, until the complete field is surveyed, is undoubtedly excellent. It discloses the particularly intelligent system used by the large libraries for cataloguing. The bulletin for last March, for example, covers metallurgy and metal working, and it enables us to comment upon the incompleteness (if not the inadequacy) of the collection of books on metallurgy and foundry practice available to the citizens of Leeds. Striking omissions are Harbord on steel, Hatfield on cast iron, and Hurst on the cupola. Now that there are so many specialised libraries in Great Britain associated with Bureaux of Information, we offer the suggestion that the chief librarians of the various city libraries should consult with the appropriate research association for guidance, both as to new purchases and the acquisition of standard works.

Copper Chemical Plant. Published by the Copper Development Association, Thames House, Millbank, London, S.W.1.

The foreword to this book states that it "has been prepared to indicate some of the applications of copper in the chemical industry and to review briefly the physical, mechanical and corrosion resisting properties upon which the use of copper depends. Some of the typical operations involved in the manufacture of copper plant are described." Beyond emphasising that the book has well performed its objects and adding that it is splendidly illustrated, we feel that we can do nothing better than state that it is available to our readers on request. It will make a valuable addition to their technical bookshelves.

Modern Foundry Management

SOME STATISTICAL METHODS OF CONTROL

By A. J. G. SMITH

German industrialists and undertakings have always been noted for the amount of attention they devote to statistics and their method of presentation, and an interesting Paper on this subject was read at the International Foundry Congress held at Düsseldorf last September by Dr. Herbert Antoine, a statistician with considerable foundry experience. It should never be overlooked that when properly handled and intelligently presented modern statistical methods enable the busy man not only to survey the past and to keep a close hold upon present happenings, but also to some extent enable him to anticipate the future. For their successful

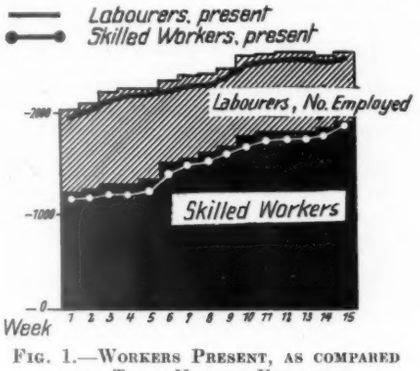


FIG. 1.—WORKERS PRESENT, AS COMPARED WITH TOTAL NUMBER EMPLOYED.

utilisation, however, they require a certain flexibility in control and presentation which is absent from bookkeeping and cost accounting, with which departments, however, it is intimately associated. In certain modern foundries, statistics have become one of the most useful instruments in the hand of the superintendent or higher management, not only in solving the problems of control but also in making provision for the future contingencies which are indicated by the method from time to time.

Dr. Antoine's Paper contained some interesting examples of methods of presentation particularly applicable to foundry conditions. One of the

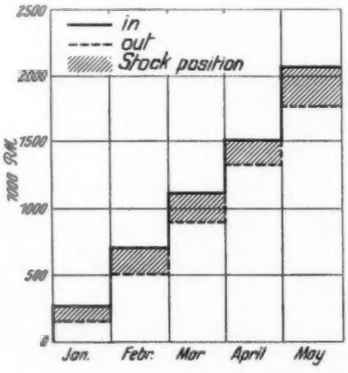


FIG. 4.—STOCK POSITION.

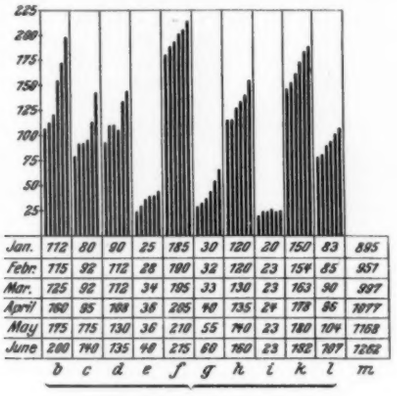
first essential matters calling for control in any works or foundry is the attendance of workpeople, upon which, of course, production is dependent, and a continuous comparison of numbers present with the total on the pay-roll is very advisable.

Fig. 1 shows how such information is regularly presented for the information of the busy foundry superintendent, while for keeping in touch with the numbers employed in different departments the method shown in Fig. 2 will be found much better than a mere table of figures or even the usual simple chart.

The problem of controlling the charges represented by unproductive labour in the foundry is materially lightened if the information showing the proportion between this and the total cost of wages is regularly presented in the manner suggested by the more elaborate method shown in Fig. 3.

Raw Material

In the average foundry it is probable that wage rate statistics are subject to closer scrutiny



	b	c	d	e	f	g	h	i	k	l	m
Jan.	772	80	90	25	185	30	120	20	150	83	895
Febr.	775	92	772	28	190	32	120	23	154	85	957
Mar.	725	92	772	34	195	33	130	23	163	90	997
April	760	95	108	36	205	40	135	24	178	96	1077
May	775	775	730	36	210	55	140	23	180	104	1768
June	200	740	735	40	215	60	160	23	182	107	1262

a

FIG. 2.—NUMBER OF WORKMEN IN WORKSHOPS.

a = workshops. *b* = grey-iron foundry. *c* = malleable iron foundry. *d* = steel foundry. *e* = pattern shop. *f* = core shop. *g* = locksmith's shop. *h* = fettling shop. *i* = tumbling shop. *k* = machine construction. *l* = shipping department. *m* = total.

than the figures relating to material. Nevertheless it is advisable to apply methods of statistical presentation to this section of the business also rather than to rely too implicitly upon the purchasing department, which after all only has a partial view of the implications involved. Apart from other reasons, the statistical method

FIG. 5.—THE RESULTS OF REJECTIONS SHOWN GRAPHICALLY.

a = "Rejections mean money thrown away. Here you see the waste through this cause in your own shop compared with the waste from all other shops." *b* = workshop. *c* = total.

also gives a regular indication of the commitments in regard to payment. On the same side of the business the statistical method should also give a clear picture of the withdrawals from stock, stock in hand, the most convenient method of presenting this information being on the lines shown by Fig. 4.

Educating the Worker

The statistical method should also be used for presenting certain essential facts to the workers, and it can be made to serve a very useful purpose in minimising the number of rejects. In order that losses through this cause may be reduced to a minimum, it is very desirable that they should be analysed in order that they may be allocated to the departments responsible. When this is done, it is possible to show to everyone concerned the real significance to the undertaking of the rejects and wasters which are sometimes treated as just a matter of bad luck. Fig. 5 shows a very striking way in which the losses through faulty work and other causes can be impressed upon the people mainly concerned. A caption at the head of the illustration states "Rejections mean money thrown away. Here you see the waste through this cause in your own shop as compared with the average in all other departments in the foundry." While dealing with the question of foundry rejects, an analysis of the reasons by means of frequency curves is

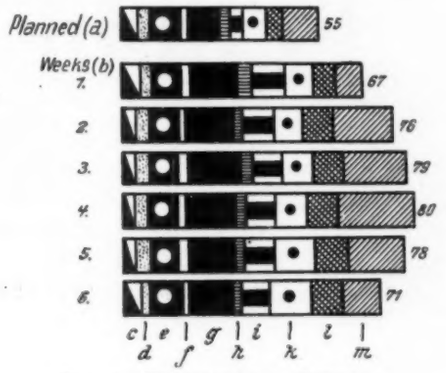


FIG. 3.—PROPORTIONS OF UNPRODUCTIVE TOTAL LABOUR.

a = planned values. *b* = week. *c* = maintenance. *d* = after treatment. *e* = inspection. *f* = instructors. *g* = sundries. *h* = transport. *i* = cleaning. *k* = stores. *l* = vigilance. *m* = leaves.

particularly instructive for any management, and such information is best presented in the manner of the example shown in Fig. 6.

Turnover

The presentation of data relating to turnover sometimes presents a little difficulty where this covers numbers of different classes of castings, but Fig. 7 shows how it is possible to present graphically in the one diagram all information

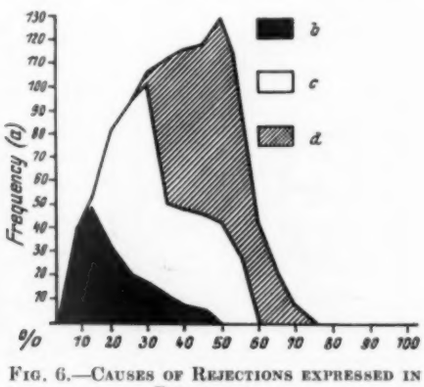


FIG. 6.—CAUSES OF REJECTIONS EXPRESSED IN PERCENTAGES.

a = frequency. *b* = faulty patterns, cracks due to stresses, etc. *c* = casting defects, slag inclusions, dirty surfaces, etc. *d* = moulding defects, porosity, pipe, etc.

relating to the output of (*a*) non-ferrous castings, (*b*) cast steel, (*c*) malleable iron, (*d*) grey iron, (*e*) proportion exported and (*f*) proportion for domestic market.

Planning

A statistical department, like any other foundry work, requires to be organised, and to

function in accordance with a well considered plan. It is not possible for the management to make the fullest possible use of the facts and indications which the new method makes available unless such data are presented regularly and in accordance with an arranged schedule. It is a regular criticism of many government returns that by the time they are available to to the business community they have the interest rather of history than a record of current events, and this is a danger that must be avoided in the foundry statistical department. The author of the Paper under review divides the control of a foundry into eight sections, and gives the suggestions set out in Fig. 8 upon the data which the foundry statistician requires to handle and the frequency with which the results should be presented.

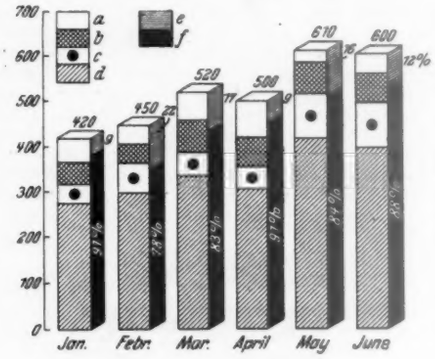


FIG. 7.—ANALYSIS OF TURNOVER.

a = non-ferrous metal castings. *b* = cast steel. *c* = malleable iron. *d* = grey cast iron. *e* = foreign countries. *f* = home country.

Although the examples selected are those dealing chiefly with the production of a foundry, the statistical method of control can be equally useful on the costing and financial side, for it is easy for the savings resulting from efficient production methods to be lost through a bad or ill-directed financial policy, Dr. Antoine's Paper gives some interesting examples of the manner of application of the method to the financial aspect of a business.

Permanent Mould Castings in Aluminium*

BY R. J. ROSHIRT.

The use of permanent mould aluminium castings, which were developed to their present state of perfection in the motor vehicle industry, is rapidly spreading to a great many other industries. As a result, the new business of this division is beginning to rival the production of pistons, cylinder heads and other familiar types of motor vehicle castings. Furthermore, permanent mould castings are usurping the field of aluminium die castings, and because of their superior qualities the Bohn Aluminium & Brass Corporation has ceased to produce die castings. Almost all washing machine agitators, for example, are now cast in permanent moulds. Permanent mould castings are also used in vacuum cleaners, automatic vending machines, electric ironers, radiators for heating, floor polishing machines, typewriters, shoe repair machines, aircraft parts and many other machine elements. These castings range in weight from 1 ounce to 25 lbs. or more.

Permanent mould castings are poured by gravity, just as in sand casting practice, except that the mould is of metal. A typical pouring operation is that on a washing machine agitator. The mould is made of steel-mix iron in three sections, each actuated by an air ram. Safety lock pins hold the mould assembly in place and assure proper registry of the inside faces. The core is also a steel-mix casting, and is lowered in place vertically by a fourth air ram. Molten metal is poured from a hand ladle through a central spout and is distributed through three gates.

The gating must be generous, particularly where the gate joins the casting proper, since gravity alone forces the metal into the mould. The gates and sprues are sawn off by handsaw, and are remelted. Fins and other projections are chipped off by air hammer, hand filed or both. With a circular casting like an agitator, it is possible to chuck the piece in a lathe and turn off the fin at the edge. Much of the cleaning work is performed on cloth or glued abrasive wheels.

High Strength of Castings

Moulds are made of steel mix or high-duty cast iron. They can be cast from wood patterns and the finishing cost therefore is low. They need not be made from the highest grade die steels and machined from the solid blank, as is necessary for die casting dies. The principal advantage of the permanent mould technique, however, is not the lessened die cost, but the fact that no air bubbles nor gases are entrapped. Hence the chilling effect of the metal mould produces a dense homogeneous metal that is at least 20 per cent. stronger than a die casting.

In die castings, the metal is forced into the die under pressure, and gas pockets and voids within the metal are trapped sometimes, and concealed under the surface of the casting. Hence, the tensile strength, yield point and elongation are higher for permanent mould castings than for either sand castings or die castings. Moreover, they can be greatly improved physically and mechanically by proper heat-treatment. The possibility of included gas precludes the heat-treatment of die castings, and for the same reason, thermal conductivity is lowered. In the polishing of aluminium die castings, porous spots or small blowholes may be opened, giving the casting a spotted or mottled surface. Permanent mould castings, having a dense homogeneous metal throughout, give a much better polish, although the initial surface is rougher. Check marks in die faces are not nearly so common in permanent moulds as they are in die casting dies. Absence of pressure may be a contributing factor. Die erosion is also lessened. A slightly mottled appearance is present, but this surface cleans up well.

Where the internal shape of the casting is such that a metal core is not practical, die casting obviously cannot be used. A semi-permanent mould casting using a steel mix iron mould and dry-sand core is practical, however, and the resultant casting possesses all the advantages of a permanent mould casting. Sand cores are shaken out in the usual way.

With many of the newer alloys, permanent mould castings can be greatly improved physically by proper heat-treatment. In fact, the availability of these higher strength alloys in cast form has created new markets for this material. Typical productions are an aeroplane landing wheel, an intricately cored structure subject to severe shock loads; and an automobile supercharger impeller which must withstand high bursting stresses at speeds of 40,000 r.p.m.

Permanent mould aluminium castings can be made with sections as thin as $\frac{3}{64}$ in., which is slightly thicker than a section feasible in a die casting. Almost any combination of properties can be obtained in permanent mould aluminium castings—high strength, high hardness, low expansion (high silicon content) and strength at elevated temperatures, such as would be required in pistons for high compression motors. Washing machine agitators are made of S.A.E. No. 33 alloy containing 6 to 8 per cent. copper, 2.5 per cent. zinc, 1.5 per cent. iron and 2 per cent. zinc. This is one of the most widely used alloys.

Typical of the high-strength, heat-treated alloys is S.A.E. No. 38, extensively used for outboard motor parts not only because of its strength, but also because of its resistance to salt spray corrosion. Strengths from 17 to 24 tons per sq. in. can be obtained with permanent mould castings, according to heat-treatment. In comparison, the No. 33 alloy has a tensile strength of not less than 10 tons when cast in a permanent mould, and 8 tons in sand. The No. 38 alloy contains the following percentages: 4 to 5 copper, 1.2 silicon, 1.2 iron, 0.3 manganese (max.), 0.2 zinc (max.), and 0.05 magnesium (max.). Other impurities are controlled to 0.20 per cent.

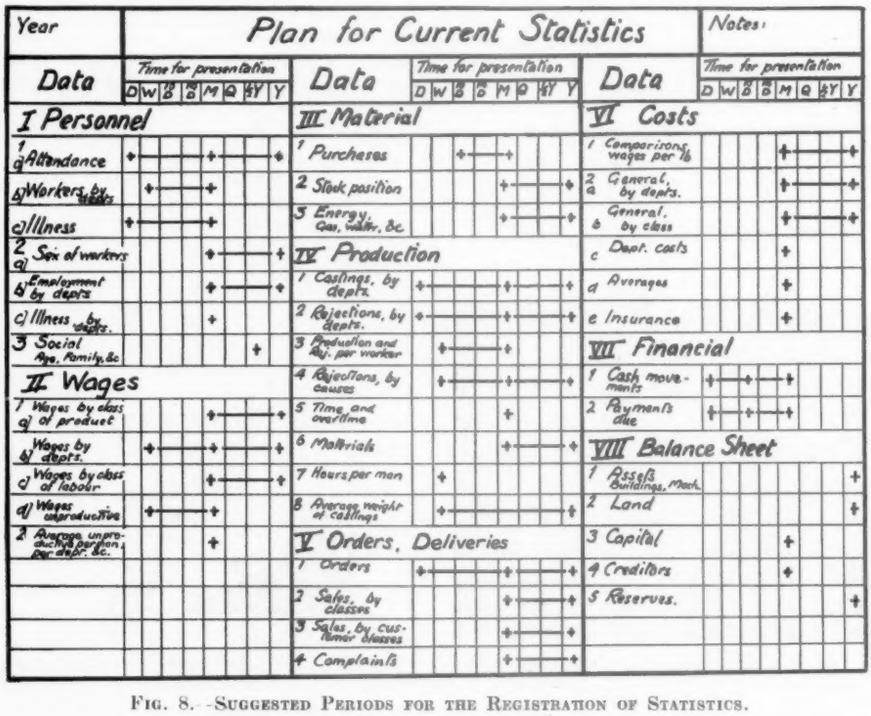


FIG. 8.—SUGGESTED PERIODS FOR THE REGISTRATION OF STATISTICS.

* From the "Iron Age." The author is manager, Permanent Mould Division, Bohn Aluminium & Brass Corporation.

The Production of Dense Iron Castings

At the meeting of the London Branch of the Institute of British Foundrymen, held last month, and presided over by Mr. V. Delport, MR. J. H. WILLIAMS presented a Paper, "The Production of Dense Iron Castings." The Paper was printed in our last week's issue.

DISCUSSION

The BRANCH-PRESIDENT (Mr. V. Delport) said that Mr. Williams had presented his Paper as the result of the invitation extended to Branch members at the beginning of the session to offer Papers or to make suggestions for the development of the Branch activities. Mr. Williams' gesture was very much appreciated, and it was an example which he would like to see followed by other members of the Branch.

The Eutectic Graphite

DR. A. B. EVEREST (Senior Vice-President of the Branch) welcomed the Paper as one of essentially practical interest and covering an immense field of interest in the production of castings.

A matter in the early part of the Paper which had puzzled him was the frequent reference to eutectic graphite, and he had wondered in what respect the author regarded its presence as dangerous. It also seemed peculiar that the author had repeated from time to time that the eutectic graphite was the excess graphite over the eutectic composition. Surely the eutectic form of graphite was the material which separated at the eutectic, and the excess would be as coarse graphite. It seemed from his experience that the eutectic graphite was a function not so much of composition as of cooling rate. By casting a high-silicon high-carbon iron in chill moulds, the author had obtained extraordinary structures. Dr. Everest had tried that and had produced test bars in which the graphite was entirely in the very fine form, which he believed was the eutectic form of graphite. Although he had expected to get very good strength properties in that material, it was not strong. Whether or not Mr. Williams's point was that the graphitic structure was not associated with the mechanical properties, he was not sure, but Mr. Williams's material was certainly very sound and very dense.

Dangerous Steel Addition Range

Discussing the use of steel scrap, Dr. Everest said it was certainly not his experience that there was a dangerous range, or a range of low strength, at between 40 and 75 per cent. of steel. He believed that with suitable control of composition one could obtain more or less continuously increasing strengths as the steel content increased. There were some test irons having 50 and 60 per cent. and even up to 85 per cent. of steel; but castings containing 40 to 50 per cent. steel were definitely good. Although there might be a tendency for the steel to become oxidised in the upper zones of the cupola during melting, surely in the higher temperature regions the tendency was to carburise, which was the antithesis of oxidation.

Dr. Everest questioned whether sulphur was really the bugbear that some people believed it to be. Recently he had been studying rolls, particularly chill rolls. The ordinary rolls in a rolling mill were subjected to so tremendous a stress that, if a piece of cold steel were put through, they would tend to break a section which was 15 in., 20 in. or even 30 in. in diameter. Yet it was the usual practice in this country to cast rolls with a sulphur chill; the aim was definitely to have sulphur in excess of the ordinary manganese/sulphur ratio. A typical composition used in Sheffield included sulphur 0.15 to 0.18 per cent. and manganese 0.2 to 0.3 per cent. That hardly resembled a balanced composition which would give the high strength that Mr. Williams had mentioned, and Dr. Everest asked for more information concerning sulphur.

Eutectic Graphite

MR. WILLIAMS replied that possibly Dr. Everest and himself were at cross purposes with regard to eutectic graphite. In all the examples he had observed—and two of which he had illustrated—nests of graphite flakes had often separated out when the total carbon exceeded the eutectic composition of the cast iron, *i.e.*, if a cast iron contained, say, 3.7 per cent. of total carbon and the eutectic point as calculated from the chemical analysis was 3.5 per cent., then he had often observed a tendency for numerous patches of closely-packed and very small graphite flakes to be formed in the metal. He had assumed this to be eutectic graphite, although it was only supposed to separate out from a hyper-eutectic iron with heavy undercooling.

With regard to steel scrap, he and others had found that there was a progressive increase in mechanical strength of the iron with steel additions up to about 30 or 40 per cent., and with a suitable mixture containing 30 per cent. of steel one could obtain an iron having a tensile strength of about 18 tons per sq. in. On raising the amount of steel scrap in the charge beyond 30 per cent. and up to about 60 per cent., he had found that not only was there no increase in the strength of the iron, but often a decrease. A 50/50 mixture had frequently given much lower tensile figures than a 30 per cent. steel mix. When, however, the steel scrap formed 75 per cent. or more of the charge, then once again there was a definite increase in mechanical strength. For example, using a charge containing 75 per cent. steel scrap, 25 per cent. pig-iron (silicon 1.2 per cent.) and alloy additions to give a cast iron having 2.0 per cent. silicon, 0.7 per cent. manganese, and 1.5 per cent. nickel, one could easily secure a tensile strength of 23 tons per sq. in. It seemed as though the matter rested on insufficient mixing with the 50/50 charges. If a receiver were attached to the cupola, it would probably eliminate the trouble. He did not dispute that Dr. Everest had witnessed good results from the melting down of mixtures containing nearly equivalent quantities of steel scrap and pig-iron, but he had always obtained better results when the pig-iron or the steel formed a preponderating proportion of the charge.

Sulphur Bogey

Mr. Williams said he was not frightened by the sulphur bogey; good castings could contain 0.12 per cent. of sulphur. The point he had tried to convey in the Paper was that, if one were running high scrap charges, the average weight of the castings must be medium. Such charges were hopeless for the *continuous* production of light castings owing to the rapid rise in the sulphur content of the metal *via* the foundry returns; within three days the sulphur might rise to nearly 0.2 per cent. With regard to sulphur in rolls, quoted by Dr. Everest, he did not think the same ideas could be applied to ordinary grey iron castings. All were aware of the effect of sulphur on the chilling of iron, but that was quite a different matter from allowing a high sulphur content to accumulate in grey iron where it could very quickly assume dangerous proportions.

Manganese Additions

MR. MCRAE SMITH, M.A., referring to the addition of manganese, said that in some cases the author had produced irons which were very dirty and which had a considerable amount of slag nuclei; the reason he had put forward was that the high-carbon manganese that was added was not completely melted, that there was not sufficient time for the reaction. Mr. McRae Smith asked whether that applied to additions of chromium also. When adding ferro-manganese which was high in carbon he was afraid one was adding manganese carbides; in the same way, when adding chromium one was adding chromium carbides. Therefore, from experience, he agreed that the use of low-carbon ferro-manganese in the form of briquettes, gave much better results.

MR. WILLIAMS agreed that when one used spiegeleisen or high-manganese pig-iron, one was adding manganese in the form of carbides, and the time during which it was subjected to a high temperature was not sufficient to enable the carbides to become dissociated. Consequently, much of the manganese passed into the molten iron without exerting any de-oxidising action and would probably result in a loss of fluidity. The effect of chromium carbides was not quite the same as those of manganese. By adding nearly carbonless ferro-chrome to the iron, the chromium was free immediately to combine with the carbon already present in the melt and the chromium carbides so formed would be uniformly dispersed throughout the cast iron. But, if ordinary ferro-chrome with 6 per cent. or more of carbon were added in powdered form to the ladle, or as lumps to the furnace charge, a good, homogeneous solution of the chromium was not so readily obtained, because carbon-bearing ferro-chromes contained segregates of carbides with a high-carbon content which were very difficult to melt and were apt to give rise to "hard spots."

MR. C. H. KAIN (Past Branch-President) asked what particular advantage the author derived from the use of silicon briquettes instead of using 25 per cent. or 20 per cent. ferro-silicon. With regard to the statement that excellent results were obtained when using railway chairs as scrap in a mixture for making dense grey iron castings, Mr. Kain said he had always found railway chairs to have a structure which was considered nowadays to be very coarse.

Use of Silicon Briquettes

MR. WILLIAMS replied that the advantages of using silicon briquettes were that they were easily handled and the melting losses were very small. If one used 12 per cent. ferro-silicon, the losses were much higher and at the same time variable from day to day. In charges in which he had used 45 to 50 per cent. ferro-silicon he could never obtain anything like such good results as with the briquetted ferro-silicon.

He agreed that the structure of railway chairs was on the coarse side owing to their thickness, and, as he had pointed out in the Paper, good machinery scrap was often much better. The only advantage in the use of railway chairs was that their composition was, for scrap metal, fairly constant. When dealing with charges containing 80 per cent. of scrap, it was necessary to have an approximate idea of its chemical composition, whereas with general machinery scrap the composition was much more variable. It was for that reason that he had found the railway chairs very convenient, though he admitted the limitation to which Mr. Kain had referred. He had obtained fairly good and quite consistent results from chairs. With regard to a heterogeneous mass of scrap, the difficulty was that one could not analyse it and had no idea of its average composition. He had tried running down half a dozen 10 cwt. charges of scrap plus alloy additions in order to get an approximate knowledge of its composition, but the results had not been uniformly successful. The scrap had been selected from all over a new heap in an effort to obtain a representative sample for the charges.

Phosphorus and Density

MR. N. BURNS drew attention to the statement in the Paper that high phosphorus content caused internal weakness, and said that he could not reconcile that with the use in dense castings of railway chairs containing 1.3 per cent. phosphorus. He pointed out that railway chairs

were of very large section in relation to total weight. Surely the use of the chairs would defeat the object of attaining dense castings.

MR. WILLIAMS replied that he had tried to divide the Paper into two sections, one dealing with the use of mixtures of foundry pig-iron and scrap iron and the other dealing with steel mixes. In many cases one could make a fairly dense casting with an iron containing 1 per cent. of phosphorus, though usually it would not be sufficiently dense for pressure work. In a locomotive cylinder, for instance, there could be 0.8 per cent. of phosphorus, and iron containing about 1 per cent. of phosphorus was used quite successfully for a large variety of castings which were dense and satisfactory. On the other hand, he agreed that in nearly all, if not all, hydraulic castings which had to pass a pressure test the phosphorus content should be low. Such castings were made with low or medium phosphorus pig-irons mixed with steel scrap and one's own remelts.

Eutectic Graphite Question

MR. L. G. HEMSLEY said that apparently Mr. Williams would have one believe that the eutectic graphite occurred when the total carbon content of the iron was above 3 per cent.

MR. WILLIAMS said it occurred above the eutectic composition of the iron, and the total carbon content might be 3.2 per cent. or something of that order.

MR. HEMSLEY said that in each case referred to in the Paper it occurred when the total carbon was above 3 per cent. He pointed out, on the other hand, that in the manufacture of a cast crankshaft for an automobile, he had found invariably that the eutectic graphite formed when the total carbon content was low, around 2.3 per cent. The silicon content was about 2.5 per cent. and the nickel content about 1 per cent. If the eutectic graphite could occur under those conditions, it would appear to bear out Dr. Everest's view that the eutectic graphite was really a function of cooling rate.

Commenting on the addition of steel scrap and the author's reference to the use of fishplates, Mr. Hemsley, who knew the railway companies favoured 14 per cent. manganese steels, wondered how the author segregated them when he bought them.

MR. WILLIAMS, replying to Mr. Hemsley, said he was greatly interested to learn about the presence of eutectic graphite in an automobile crank-shaft containing 2.3 per cent. of total carbon. From the low total carbon this would be a hypo-eutectic alloy iron. One did not notice the occurrence of eutectic graphite in hypo-eutectic cast iron very often, and it could only occur in such iron when solidification took place with heavy undercooling.

MR. HEMSLEY said the iron he had referred to was made in one of the best malleable iron foundries in the country.

MR. WILLIAMS, dealing with the question concerning steel scrap, said that he had not used fishplates for some time, but he had never experienced the difficulty arising from a consignment of fishplates containing some made with high manganese steel. The results of using such high manganese steel for plain steel would be useless. He did not see how one could readily get over the difficulty of a consignment of ordinary plain-carbon steel fishplates contaminated with some of high manganese steel.

DR. EVEREST suggested that a magnet would detect it immediately.

MR. WILLIAMS replied that it was not a practical proposition to treat a batch of fishplates with a magnet.

MR. HEMSLEY pointed out that even if there were only one high manganese fishplate in a charge it would increase the manganese content of that charge to 2 or 3 per cent.

MR. WILLIAMS said he still did not consider that it was practical to go over the charge of fishplates with a magnet. If one suspected trouble in this direction it would be better not to use them.

MR. BURNS suggested that the percentages of phosphorus referred to in the Paper were rather high, particularly bearing in mind that the aim was to produce dense castings, which he assumed had to be machined for some special purposes and had to resist wear or pressure or had to be of high strength. In his experience phosphorus in the quantities mentioned in the Paper was disastrous from the machining point of view. There was a very objectionable chatter on the lightest section castings containing 0.3 per cent. phosphorus and with the larger sections there was even more trouble.

MR. WILLIAMS pointed out that a very large number of castings containing 1 per cent. of phosphorus was made in the London area; they were quite good castings and the bulk of them had to be machined. It might be that the presence of 1 per cent. of phosphorus would render the iron less easily machinable but he did not think it would interfere to much extent. One per cent. of phosphorus meant the presence of 10 per cent. of phosphide eutectic—a somewhat hard and brittle constituent—which would tend to increase the general hardness of the metal. When he spoke of castings made with 1 per cent. phosphorus iron, he had not stated that such iron was suitable for any and every casting, for quite clearly it was not. Nevertheless, a number of fairly good castings of moderate strength and quality and a close fracture could be produced in phosphoric cast iron.

MR. BURNS said that even 0.6 per cent. phosphorus might cause trouble in castings of heavy section.

MR. WILLIAMS agreed that it might in a heavy section. He asked if Mr. Burns had in mind a section of more than 2 or 3 in.

MR. BURNS said that he was referring to sections greater than 1 in.

MR. WILLIAMS admitted that it was much easier to make a sound casting with a low phosphorus iron than when the phosphorus rose to 0.6 per cent., but that did not mean that it was impossible always to make a casting sound in an iron with 0.6 per cent. phosphorus. He would not maintain that the casting would be as dense as pearlitic low phosphorus iron. It must be borne in mind that founders were called upon to make a quantity of castings cheaply, and one way of doing that was to take advantage as far as possible of the cheap phosphoric pig-irons made from home ores. The job and the purpose for which the casting was required should be considered before the analysis was decided upon.

Vote of Thanks

MR. V. C. FAULKNER (Past-President of the Institute), proposing a vote of thanks to Mr. Williams, commented that when the Institute had published its first report on cast iron everybody had thought that the whole of the difficulties that had been experienced in producing dense castings were overcome; the work in connection with that report had been done very largely by Mr. Walter West, who had devoted a great deal of attention to phosphorus. More recently Mr. Wynn had tackled the problems of manganese, and again it was thought that all the difficulties had been solved. Then Mr. Williams had presented his very interesting Paper, and apparently we still did not know where we were.

Continental Practice

MR. L. W. BOLTON (Birmingham Branch), commenting on the suggestion that no reference to silica slime was made in the Paper, said Mr. Williams had mentioned that he thought the coarse graphite produced in castings when coarse-graphite pig was used was not so much due to failure to take into solution the graphite flakes in the original pig, but was due rather to crystallites or particles of silica or other oxides present in the pig acting as nuclei for the formation of further coarse structures. It had been stated in the Paper that if a percentage of steel were added to the charge, even if coarse-graphite pig-irons were used it was possible to produce fine structures; and it had also been said that steel oxidised in the upper zones of the cupola. It would be agreed, said Mr. Bolton, that some oxidation of steel did take place and it was possible that the iron oxide that was formed combined with the silicon and manganese in the iron to form a very fusible silicon-manganese-oxide slag. Possibly that slag might help to remove the crystallites or oxide inclusions in the coarse pig-iron and so remove the nuclei, the result being the formation of much finer structures. It was certainly a fact that even with fairly small percentages of steel one could use coarse graphite pig without danger of having the coarse graphite structure in the resulting castings.

Discussing the author's reference to the difficulty of maintaining or improving the strengths of mixtures when more than a certain percentage of steel was used, and the statement that apparently that difficulty was not experienced so much on the Continent, where it was the practice to use receivers, Mr. Bolton emphasised that if a mixture were used containing steel with pig-iron, and possibly ferro-silicon, in the cupola it was very important to be sure that good mixing of all the components of the charge was obtained. Far too little attention was paid to this point, as a general rule, in this country and it was possible that better results said to be obtained on the Continent from high steel mixtures were due to the more complete mixing of the metal in the receiver. If a receiver were not used, good results could be obtained by using small charges, and keeping the well full of metal; or, if temperature were not of great importance a large ladle could be used for mixing. Mr. Bolton seconded the vote of thanks to Mr. Williams for his interesting and comprehensive lecture.

The vote of thanks was enthusiastically accorded.

Author's Reply

MR. WILLIAMS, responding to the vote of thanks, said he was glad that his remarks had not been received without a good deal of discussion, for he believed that it was from the discussion that much benefit could be derived. With regard to phosphorus, which had created considerable discussion, he had not maintained that dense castings could always be produced with a high phosphorus iron; but one had often to produce a cheap casting which was moderately strong and dense, and in order to help to keep down the costs one would use some cheap phosphoric iron if possible. Provided one could use it, well and good, but it had its limitations. Generally, it could not be used for pressure castings.

It was true, as Mr. Bolton had said, that good mixing was essential. Insufficient mixing was often the great trouble with steel scrap mixes and it was very difficult to melt phosphoric pig-irons with steel scrap successfully. To obtain satisfactory results easily, hematites, low-phosphorus or medium-phosphorus pig-irons should be employed. This would ensure that the range between the melting point of the steel and the pig-iron was not too great. It was also necessary to ensure that any alloy additions were so added that their constituents became homogeneously distributed throughout the molten metal.

AT A MEETING of the Bengal Iron Company, Limited, held recently, resolutions placing the company in voluntary liquidation and authorising the liquidators to carry into effect the agreement between the company and the Indian Iron & Steel Company, Limited, were carried unanimously.

Cast Crank Shafts*

METHODS USED IN FORD'S CANADIAN FOUNDRY

A little over a year ago, an electric furnace foundry was placed in operation by Ford Motor Company of Canada, Limited, Windsor, Ont., to manufacture cast crank shafts, which operation was unique in Canada. This is stated to be a superior part to the forged crank shaft formerly used. Whereas, in tests, the forged shaft showed measurable wear up to 10,000 miles of car operation, the cast shaft shows less than two ten-thousandths of an inch. This year, however, the foundry at Windsor has been doubled in capacity, and a much larger list of parts is now being manufactured.

In addition to the crank shafts, cam shafts, rear hubs, brakes, fly wheels and clutch plates are now cast in this foundry. Two electric furnaces with a capacity of 5 and 3 tons respectively take care of the crank shafts and hubs, there being two moulding lines for these parts. All other parts are made in green sand moulds, and two Brackelsberg furnaces have been installed to supply the molten metal.

This furnace is a horizontal cylindrical unit, which revolves slowly, being fired with pulverised coal at one end. The gases pass through the other end to a vertical stack, and when ready for charging the connection to the vertical stack can be removed temporarily. In pouring, the furnace is rotated so that a spout on the side is tilted to a convenient angle and the refractory plug is broken. When the ladle is filled, the furnace is rotated back again until another ladle is in position, when it is again tilted to fill the ladle. When all metal has been removed, the furnace is tilted so that the slag flows out at the end on to the floor.

To recharge the furnace the mixture of pig-iron, scrap, etc., is placed in a horizontal tray and lifted by means of the overhead crane to a platform over the furnace. When ready for charging, a hydraulic ram tilts the tray, so allowing the charge to slide into the furnace. Coal is used as the heating medium, and this is placed in a hopper over the furnace, the hopper being loaded in a pit over which trucks bring the special coal with a low sulphur content. When the hopper is filled, it is lifted by the crane and placed in position over the furnace. From here the coal is fed to the mill, where it is pulverised and blown into the furnace.

The moulding for the various parts such as clutch plates, fly wheels, and brake drums is carried out in green sand. The moulds are all made on a special turntable, which rotates from one station to another, a man at each station performing one operation of the moulding. When completed the moulds are placed on an overhead conveyor from which are suspended special carriers. The moulds remain on the conveyor until the molten metal is ready for pouring, the pouring operations being carried out on the conveyor. They then proceed to the shake-out where the castings are removed and the sand reconditioned for use again.

Crank Shaft Moulding

The manufacture of crank shafts and hubs is a different proposition and is performed on two separate lines. In the manufacture of the crank shaft, the job is entirely a dry sand proposition, made entirely from cores. The sharp sand as it is received is usually very wet, consequently it is necessary to pass it through a dryer, heated to a temperature of 150 deg. to 175 deg. C. to drive off this moisture. It is then stored in bins over the mixer.

The "bank" sand contains more clay and is used to keep the core from sagging before baking, and it also produces a smoother finish to the core. It does not require to pass through the dryer unless its moisture content exceeds six per cent., and it is on very rare occasions that this happens. A mixer with a capacity of 1,000 lb. is used, the mixture consisting of three parts of sharp sand, two parts of bank sand and silica flour, cereal binder and linseed oil added.

It requires approximately 500 lb. of sand to fill the 16 core boxes, which go to make up the mould proper. This means that 27.5 tons of regular sand per day are required to produce 400 crank shafts. A stiffer and heavier sand is necessary to make the core boxes, 4, 5, 10, 11, and also the locator and strainer cores. In this mixture, more silica flour, cereal binder and linseed oil are added.

The complete mould consists of 31 distinct cores —two of these, the 14 locaters and strainer, being made on the bench, and the balance being made on a turntable. In fact, the casting itself is really produced from the cores made on the turntable.

Operations Analysed

There are twelve distinct operations at the turntable as follow:—

(1) Clean core box. This is carried out by means of a spray, using a mixture of 19 parts kerosene and one part linseed oil. After spraying the box it is dried with a blast of air in boxes 4, 5, 10 and 11, a round paint brush being required to get down into the core points.

(2) Special sand is placed in the core prints in boxes 4, 5, 10 and 11, a stick being used to ram solid. A layer of normal sand is placed in the bottom of each box before going under the Sandslinger. This is essential as it reduces the erosive action of the Sandslinger when filling the box.

(3) In boxes 4, 5, 10 and 11 there are four core prints in each box. Into each print is placed a piece of No. 9 black annealed wire, $2\frac{5}{8}$ in. long, $1\frac{5}{8}$ in. being in the print, the other one inch protruding into the body of the core. This is necessary to keep the prints from breaking off during cleaning and assembly.

(4) A Sandslinger is used to fill the core boxes, the machine being supplied with a 16-in. head, 16-in. impeller and being operated by 15 h.p. motor at 1,200 r.p.m. When operated to capacity, this machine is equal to 208 cores per hour, 13 moulds per hour, 52 crank shafts per hour. To fill the box, the machine is passed across the centre of the box and then around the edges, then filled up to about $1\frac{1}{2}$ to 2 in. above the top of the box.

(5) With the aid of a hard rubber peen fitted to a pneumatic rammer, the edge of the core box is tamped around. The reason for this operation is due to the fact that the Sandslinger does not always pack the corners of the box solid. If the corners are weak and friable, the core would crumble while being handled in the dry end and on assembling the mould.

(6) A pneumatic air rammer with a disc end is used to butt ram all over. This covers the entire back of the core. The disc eannot get into the corners of the box, hence the use of both peen and disc.

(7) When the box comes from the butt rammer there is probably $\frac{3}{8}$ to $\frac{1}{2}$ in. of surplus sand which must be removed so that the core will be exactly to size in depth as the box. This is accomplished by the aid of a strike-off bar made out of steel 30 in. long, 3 in. wide, $\frac{3}{4}$ in. thick, and $4\frac{1}{2}$-in. handle on each end. It has a bevelled edge on both sides. In the rough strike-off, the movement should be from corner to corner of the box, leaving the loose sand on the box. The condition in which this sand is left on the box determines the class of job produced in the next operation.

(8) The finish strike-off is one of the most important operations in the making of the job, and it is by paying close attention to this operation that the foundryman is able to hold the over-all dimension of the crank shaft to the machine shop limits. This operation is performed with a steel bar 26 in. long, $1\frac{1}{2}$ in. wide and $\frac{3}{8}$ in. thick flat. The sand is removed from the back of the core until it is absolutely level and in perfect alignment with the face of the box.

(9) A core plate made of cast iron, $22\frac{1}{2}$ in. by $21\frac{1}{2}$ in. by $\frac{3}{8}$ in., and well ribbed so that it will hold its shape while going through the oven is next attached. Very close inspection is maintained on core plates. Should warpage be encountered, it will destroy the shape of the core while travelling through the oven, as the core will always assume the contour of the plate.

(10) The next operation is to turn over the core, this being accomplished with a 22-in. moulding machine with a 5-in. draw, fitted with a vibrator. This machine has a pair of clamps mounted on it, which when closed hold the core plate in position to the face of the box while rolling over the core box.

(11) The box with its core plus core plate rests on the table of the machine. The clamps are released, the vibrator is turned on and the box is drawn away from the core by the aid of a hand lever, leaving the core on the core plate. The box is returned to the table. At this stage the core is inspected for soft spots and weak ramming or other defects.

(12) The core and its plate are picked up by hand and placed in the oven. Care has to be taken not to jar or shake while the operation is being performed.

Labour Required

The turntable operations are carried out by seven men, five being inside the table and two outside. In the inside, one man carries out the first three operations while four men take care of the next five operations, leaving the two outside men to take care of the last four. For the production of 400 crank shafts, 100 moulds are required, these being made in 8 hours. The five men working inside the turntable produce 200 cores per hour.

The locator and strainer cores are made on the bench from a 50-gang box, that is, every time the box is drawn, 50 locater cores are produced, while with the strainer core a 10-gang box is used producing 10 cores with each draw of the box. The strainer core is made from special sand and must be hard and tough, so that there will be no washing of the sand into the mould while pouring. Not only does this core strain the metal for any impurities such as small portions of slag, but it also regulates the pouring time of the job. It has twelve $\frac{1}{2}$-inch holes and, after baking, these holes are reamed out so that any fins which may be in the holes will be removed. This core is dipped hot from the core oven into a silica wash, which also enhances its properties to resist the eroding effect of the metal.

Core-Oven Practice

Drying of the cores is carried out in a single compartment continuous vertical conveyor type core oven, 9 ft. $2\frac{1}{2}$ in. wide, 9 ft. 6 in. deep, 42 ft. 1 in. high, with carriers 2 ft. 1 in. high, 2 ft. wide and 7 ft. 5 in. long, each carrier having three shelves, with variable speed. The oven is furnished with two burners, each having 1,500,000 B.T.U. per hour capacity, using natural gas at 25 lbs. pressure, this being automatically controlled.

The capacity of the oven is 36 racks with three shelves, making a total of 108 shelves. Four cores can be placed on one shelf, giving a total of 432 cores, which are sufficient for 27 moulds or 108 crank shafts. From the time the

* From "Canadian Machinery."

cores enter the oven until they are brought out at the exit end, occupies four hours. Of this four hours, 2½ hours will be taken up in baking, 45 minutes from the time they are placed in the oven until they reach the baking zone and 45 minutes to cool to a point where they can be handled by hand. A temperature of 260 to 285 deg. C. is necessary to bake the cores thoroughly over a period of 2½ hrs.

Finishing Operations

The core, when taken out of the oven, is placed on a conveyor, and the finishing commences at this stage. Altogether, seven operations are required, these being as follow:—

(1) *Gauging and Patching of the Core.*—Gauging consists of placing a straight-edge on the surface of the core to make sure it is perfectly level. If it is not level, it is rubbed down with a carborundum stone until level. However, if the core has sagged considerably, it is scrapped at this point. Each of the cores has a depth gauge, as there are only two cores of the 16 with the same depth or thickness, namely, Nos. 7 and 8. There should be very little patching needed if the boxes are kept clean, the sand in good condition, the ramming perfect and no sticking in the draw.

(2) *Brushing with Core Wash.*—It is necessary to brush by hand the core prints on core 4, 5, 10 and 11, also the shaft of the crank shaft proper to withstand the washing and eroding action of the metal. The materials used in the making of this wash are bentonite, silica flour, clay flour and water.

(3) *Spray.*—The spray is used on the balance of the face of the cores. In the 16 cores there are eight male and eight female prints, and a cover is used to protect these while spraying, as no spray or wash is allowed on these prints, the allowance being so scant that even a filament of spray will not allow the perfect interlocking of the male and female. These covers are made of cast iron and should be placed on the male and female prints after the first operation.

(4) *Oven.*—After the cores are brushed, washed and sprayed, they are passed through an oven. This oven is about 5 or 6 ft. long, equipped with gas jets, so that as the core passes through the oven for a distance of 5 or 6 ft., a continuous gas flame plays on the face of the core, drying the core and leaving a fine white filament where the wash or spray has been applied. As the brush wash is heavier, it is more prominent than the spray.

(5) *Touch Up.*—After the core comes through the oven, the workmanship applied in the wash and spray operations is easily detected, and if it is necessary to touch up any spots which may be omitted, they are now done. All prints and the face of the cores, including the gates, sprue, runner and risers, must have this fine filament of silica wash to protect the mould from the scouring action of the metal. Particular attention is also paid at this point to see that no wires are protruding through the prints of cores 4, 5, 10 and 11.

(6) *Place Chills and Final Assembly.*—There are four copper coated cold rolled steel chills, ¾ in. in diameter and 2⅜ in. long, used in core No. 3. These are necessary due to the fact that the machine shop has to drill an oil hole in the first flange of the crank shaft, and when doing so before the chill was used porosity was encountered and it was not possible to hold the drill. The chill was, therefore, resorted to, and as the chill acts as a filler, there is now no danger of running into trouble in the machine shop. This chill is embedded in a high temperature paste, and as it is heated before insertion it takes a very firm seat, and also eliminates any sweating before pouring. There is one chill to each crank shaft.

The final inspection consists of going over each core, examining the entire job and making sure the cores are all in first class condition for storage, that is, to see that the paste is thoroughly dried and chills firmly embedded. If the paste should be wet while pouring the job, blow holes will be encountered. If the core wash or spray does not cover the face of the job with a uniform filament, then dirty castings will result, causing extra labour and material to clean them at the shot blast. If the sand is weak, it has a tendency to manifest cracks, so that when the mould is poured, the metal may break through and a run-out will result.

The cores must be in perfect condition to receive the metal, which is poured at a temperature of 1,460 deg. C. The more perfect the core is to withstand the erosion at this temperature, the easier the job will be to clean, and a better finished casting is produced.

(7) *Transfer to Storage.*—This consists of piling the cores on a storage conveyor. The locator cores and strainer cores are packed in boxes and placed in storage. Should the locator cores have any fins, they can be removed at this point. Altogether, seven men are required to take care of all operations in the dry end of core room. Two men operating on the gauging and patching, two men on brushing core wash, one man on spraying, one man on touching up, inspecting and placing chills, and a seventh man transferring cores to the storage.

Mould Assembly

In the mould assembly the bottom board of the mould must be absolutely clean before commencing the assembly of the mould, so every bottom board is wire-brushed and scraped if necessary before starting to assemble. The bottom board is provided with two locating prints cast into the plate, and these locators fit into two holes, one on each side of No. 1 core. In the mould assembly core No. 1 is first placed with its green side on the plate, the locating prints on the plate fitting into two holes provided in the core for this purpose. The washed and sprayed side of the core is to the top. This core has also dummy gates which enables the enclosed air to be driven out when pouring the job.

No. 2 core with spray or wash face is now placed facing the sprayed face of No. 1 core, leaving the green side of the core up. No. 3 core, with its green face, is now placed on the green face of No. 2 core, each core having a tell-tale at the side so it is impossible to go wrong in the assembly of the cores.

A locator core is placed in each of the holes (one on each side) of core No. 2, so that when No. 3 core is placed in position it is interlocked with No. 2 core, a special tool being required to press the locator cores into position.

No. 3 core being in position with its spray side up, No. 4 core is now placed in position with its spray side down, the locator core being placed in No. 4 before being set. At this point an iron band is placed around this core to withstand the pressure of the iron being poured to prevent any chance of a break-out of the metal.

Building up in this fashion until No. 10 core is reached, another band is placed around this core and the building-up carried along the same lines until No. 15 core is placed in position. At this point the strainer core is inserted in position in No. 15 core. A sheet of brown paper is placed on top of No. 15 core to keep any fine sand or dust from entering the mould. No. 16 core is then placed on top without any locator cores, so that it can be adjusted to suit the weight on the top of the mould. No. 16 core consists only of the runnerhead, sprue and risers. Hence there is no accurate alignment required with No. 15 core.

A weight is now placed in position and the tie rods tightened, a special tool being used to tighten up the rods. The mould should be tied down securely so that there is no chance for any metal to seep out between the cores. Every core box represents a certain part of the crank shaft and should any trouble occur in any part of the casting, it is easy to detect as to what particular core box it belongs to, as a parting line is shown between each core when the casting is poured. The pouring gates of the job are located in boxes 6 and 7.

Metal Conditions

The furnace equipment consists of two electric furnaces having a capacity of 5 and 3 tons respectively. The melting time of the furnaces is 75 minutes, refining time 45 minutes, pouring time 15 minutes and charging time 15 minutes. The charge for 25 moulds or 100 crank shafts is 5 tons, and is made up of borings, stampings, forgings, pig-iron, tool steel, copper and ferro-chrome in quantities to produce the correct specifications.

The metal is tapped from the furnace into the pouring ladles at a temperature of approximately 1,490 to 1,510 deg. C., the pouring ladles being kept hot by means of a gas jet. The ladles are 17 cwts. capacity, but lined down to about 13 cwts. capacity. The lining can be either 2-inch brick or ganister. A core is inserted in the ladle, leaving a space of 2 in. all around the ladle, and this is the ladle lining. As it requires 4 cwts. of metal to fill one mould, 12 cwts. are required to pour three moulds, so when filling up the ladle at the furnace an endeavour is made to hold the contents to as close to 12½ cwts. as possible, thereby cutting down the heel left in the ladle to a minimum.

Before pouring, the top of the mould, which is core No. 16, is covered with a sheet metal cover, leaving only the runner head open to receive the metal. This cover is essential, owing to the fact that sometimes, no matter how careful the pourer may be, some metal may splash over into the risers and chill, causing cold shots in the castings.

The pouring temperature of the iron at the mould is checked with an optical pyrometer, due to the fact that the temperature is necessary to run the job, and any excess temperature over 1,470 deg. C. will produce a coarser crystalline structure in the metal. As one ladle will pour three moulds, a drop in the temperature of about 40 degrees may be expected between the first and third moulds, and if the temperature is the only indicator of fluidity to the job, close attention must be paid to the pouring temperature, otherwise misruns will result.

In order to reduce shinkage to a minimum during the period of solidification of the casting in the mould, it is essential that the mould be provided with risers, shrink gates and a special sprue to act as feeders while the metal passes from the liquid to the solid condition.

Pouring and Stripping

The risers and runner head are covered with charcoal in order to slow down the solidification time of the metals. After the mould is poured off, it is allowed to stand for three hours without touching any of the cores, or, in other words, the crank shaft is subjected to a more or less annealing effect, for it is essential that the casting be cooled uniformly at this stage. If taken care of here, the heat-treating operation will be more efficacious as to the physical results and the machinability of the casting.

Cores 15 and 16 are removed and the cluster of the four crank shafts, with its risers, sprue and runner head, is now attached to a vibrator, and through the vibration created the sand is loosed from the casting. During the cooling operations the moulds on the conveyors pass through a covered oven where they are allowed to cool slowly, the ovens being fully ventilated by exhaust fans. While the vibrators are working, the knock-out men can hasten the operation by breaking away the cores with a wooden maul or crowbar.

The cluster with its cores removed now enters the cleaning room. Needless to say the sand is too burned for further use and is all discarded, since this is a core proposition entirely. The

cluster is taken off the reel with a chain hoist and placed on the floor. Here, with the aid of special crowbars, the crank shafts are detached from the sprue, the risers removed from the castings and the gates broken off. The sprue is broken in half with the sledge hammer, and the sprue risers and gates returned to the melting department as back stock, a special rubber cradle being used for breaking sprue.

Fettling the Castings

From here the crank shafts are placed singly on a conveyor and a spot is ground with a hand grinder for the heat number to be stamped on. If in later tests one of the crank shafts should be found imperfect, then by means of this number the heat can be found and all other crank shafts discarded.

In the next operation the crank shaft is passed on for the removal of the wires, which are placed in the core prints in boxes 4, 5, 10 and 11, to strengthen the prints when making the cores. There are four 2⅝-in. long wires per crank shaft, and these are pulled out with a pair of pliers. The fins are knocked off with a hammer or chisel.

The sand in the lightener holes is now reamed out with a special reamer attached to an offset hand grinder. The crank shaft then passes to the shot blast chamber, being conveyed to this department on the conveyor. While still on the conveyor a double spray of No. 19 shot is played on it for two minutes or more to remove all adhering sand. The length of time required to clean the crank shaft thoroughly depends on the severity of the burning of the sand.

From here the crank shaft passes on to a double head stand grinder, provided with 18-in. by 2½-in. by 2-in. wheels of a 16/20 grain, where the gates and risers are ground. It is then passed on to another double head stand grinder provided with 20-in. by 1½-in. by 2-in. wheels of 24/36 grain, where the contours are ground. Passing on to a third double head stand grinder, provided with 18-in. by 1-in. by 2-in. wheels of a 24/36 grain, the centre bearing dip in Nos. 1 and 4 contours, and flash on side of contours 1 and 4 are ground or snagged.

From here the crank shaft is passed on to an air reamer, where the lightener holes are reamed out with a special reamer. After the holes are reamed they are blown out with air, using an air hose and nozzle. The scaled spots are now ground off with an air grinder and the crank shaft passed on for the next operation, which consists of drifting all core holes with chisel and hammer, grinding outside diameter contours with the air grinder, and reaming core holes if required.

Scleroscope Tests

MR. JOSEPH G. GAGNON, writing on "Hardness Tests Equipment and Operation," in a recent issue of "Metal Progress," states, with regard to the scleroscope test, that low readings may be due: (1) To friction from dirt in the glass or on the hammer. (2) To clogged vent holes in the bottom cap of the barrel which interfere with the escape of air under the falling hammer. (3) To a loose diamond. (This may be determined under a magnifying glass by tapping the stone lightly.) (4) To being out of plumb. (5) To striking a glancing blow when impacted surface is not level.

High readings may be caused: (1) Under exceptional conditions by wear on the diamond point. Hammers that read too high should be redressed and restandardised. This can be determined by use of standard blocks. (2) When the valve ball becomes clogged with dust so that it cannot set properly some air will enter the glass tube chamber, which causes the hammer to drop with a greater velocity, with the result that abnormally high readings will be obtained.

Quieter Times in Copper

BY "ONLOOKER."

The advance in copper seems temporarily to have petered out, and although it is suggested that when the next buying movement materialises, possibly in the early months of next year, the upward trend will be revived, no one seems prepared to bank on any spectacular changes during the next six weeks or so. For one thing, that time of the year is approaching when stocktaking intervenes, and buying diminishes accordingly, and it must not be forgotten that there is still a fairly large speculative account open and that holders in a good many instances will probably decide to take their profits before Christmas. The possibility of a bear raid is always present, and in this connection one must remember that production is now at 105 per cent. of the agreed tonnages—on paper, at any rate—a figure which, in the writer's opinion, is definitely in excess of consumption. From the top quotation there has been a reaction of about 40s., and at the time of writing electro stands at £49. This level is well over that which, it was understood, the producers had in mind when they set out by means of a curtailment plan to improve the price of their product. According to published costs, some of them are certainly doing very well at present.

Production and Consumption

Nobody can deny that there has been a great deal of speculation in the standard market, and that as a result the inevitable price advance—inevitable because consumption was increasing in a very marked manner—developed much more quickly than it would otherwise have done. In other words, an upward movement which would normally have occupied perhaps three months was compressed in as many weeks, and in that brief period consumers, fearing to miss their market, came in with a rush and covered their needs for many months ahead. It is not suggested that buying has entirely spent itself; obviously, there will be day-to-day purchasing. It is the writer's contention, however, that the volume of consumption represented by this latter falls much below the tonnage output equivalent to 105 per cent. as fixed by the combined producers outside the United States. The position therefore seems to be that any considerable volume of selling by speculators would find the market rather short of buyers, for, as already explained, consumers are resting on their oars, and for the present, and at its current level, copper is not particularly attractive to speculators.

The position of copper in America is not at all dissimilar from what it is here, except that there is no bull account open on the National Metal Exchange. Users of copper bought freely at 10 cents and again at 10¼, the cover thus secured reaching well into next year; since the advance to 10½ cents they have been less in evidence. Nevertheless, business is not unsatisfactory, and there does not seem a chance of a setback in the quotation. As a matter of fact, optimism runs high, and 11 cents is mentioned as a distinct possibility in the fairly near future. However, no upward movement in New York appears to be likely this year, and what will probably happen will be a joint advance in London and New York in the spring. For the present, copper must expect weak days on the London market, of which advantage should be taken by trade buyers.

THE GENERAL ENGINEERING COMPANY (RADCLIFFE), LIMITED, in which were offered for sale last week 550,000 ordinary 2s. shares, at 3s. 6d. a share, has been formed to acquire a general engineering business specialising in the supply of plant and machinery for the electrical industry.

Catalogues Received

Fire-Cement Gun. J. H. Sankey & Son, Limited, Ilford, Essex, have sent us a folder which illustrates and describes the "Pyruma" gun. This apparatus is actuated by an air pressure of 40 to 50 lbs. per sq. in. and consists of a tank, 1 ft. 2 in. dia. by 1 ft. 5 in. high, provided with handles for transport and reinforced to carry piping. Attached by stout tubing is an ejector nozzle. Gunmetal has been used for both the suction piece and the ejector and its valves. The total weight is 31 lbs. The idea of spraying brickwork is somewhat novel in this country but has much to commend it. It gives a stress-free surface and if the correct type of refractory is used, one which has very great heat and slag-penetration resisting qualities. The machine is of such a low price that it is worth acquiring purely for experimental purposes, for on theoretical grounds at least it shows great promise. If the machine becomes popular, as we believe it will, we suggest that the suction tube could be shortened and a rotating paddle could be fixed to work beneath it. This folder is available to our readers on request.

Electric Furnaces. A folder received from Metalectric Furnaces, Limited, Cornwall Road, Smethwick, Birmingham, contains five leaflets appertaining to electric furnaces, some of which have previously been reviewed in our columns. Those folders not so dealt with include one devoted to re-circulated-atmospheric furnaces, carrying two illustrations of a 25 ft. long by 3 ft. 6 in. diameter furnace for annealing nonferrous sections at the rate of 10 cwts. per hr. No. 5 leaflet illustrates an aluminium forge furnace of 45 kw. capacity operating at 400 to 500 deg. C., whilst No. 3 deals with a range of "circle" high temperature (1,000 to 1,350 deg. C.) resistance furnaces. Five sizes are listed varying from a chamber size of 9 in. by 6 in. by 6 in. to 24 in. by 12 in. by 18 in. The idea of sending a folder is quite good as normally single leaflets are liable to be misplaced.

Book Review

Printing Metals. Published by Fry's Metal Foundries, Limited, Tandem Works, London, S.W.19.

This is an excellent example of the service given by the leading firm in a section of industry to its customers. It is purely an attempt to give to clients real knowledge of a range of materials they habitually buy and use. Moreover, it covers a branch of metallurgy, about the general details of which the average metallurgist is lamentably ignorant. For the practical man handling these metals in a printer's foundry there is a wealth of really practical information.

A rather striking omission has been made inasmuch as no magnifications have been given for the extraordinarily good photomicrographs which are produced. For instance, Plate II would look very much like Plate I if the former had been photographed at a higher magnification. If the magnifications had been given, the collection would have been of enhanced value.

The paragraph on microstructure could have been usefully enlarged to detail this and also to give more explicit information on etching reagents. The book, with its appendices and an excellent index, comprises just over 100 pages.

A PETITION for the confirmation of the reduction of the capital of the Hume Pipe & Concrete Construction Company, Limited, from £610,000 to £38,419 was heard before Mr. Justice Crossman last Monday.

Shortage of Skilled Labour

APPRENTICE TRAINING NEGLECTED

At the November meeting of the Sheffield Branch of the Institute of British Foundrymen, Mr. J. Roxburgh presiding, a short Paper competition was conducted. The Papers, for the best of which two prizes were awarded by Mr. Roxburgh, were judged by the audience by ballot, and the identity of the authors of the Papers was not disclosed until after the voting.

The BRANCH-PRESIDENT (Mr. J. Roxburgh) said he believed five of the six authors had not written Papers before, which, he thought, was very good. Members of the Council would read the Papers in the order in which they had been drawn, as it had been thought that the first Papers might receive more attention than those presented later.

The following Papers were then read in the order given:—"These Foundry Apprentices"; "Patternmaking for Moulding"*; "Selection of Silica Sands for Steel Castings"; "Co-operation between Foundry and Melting Shops"*; "Steel Moulder's Composition"; and "Detrimental Factors Affecting Steel Castings."

The winning Paper was "Co-operation between Foundry and Melting Shops," which received 25 votes; the author was Mr. J. H. Pearce, English Steel Corporation. The runner-up was Mr. H. Brittain, of Newton, Chambers & Company, Limited, who received 23 votes for his Paper on "Patternmaking for Moulding." The Branch-President presented to the two authors prizes of two guineas and half a guinea respectively.

Poor Local Response

MR. R. C. TUCKER, commenting on the Paper concerning apprentices, said that the Rotherham Technical College were trying to organise a course on foundry work, and he had been asked to be the teacher, but only six students had enrolled. It appeared that foundry apprentices have to be pushed into the classes, but they should not be pushed into them without practical and immediate recompense. He believed that firms enlightened enough to have apprentices should give them every opportunity not only in the foundry itself but in helping them with their evening studies.

Regarding the Paper "Detrimental Factors Affecting Steel Castings," the top bar had a tensile strength of 31 and the bottom one 31.9, but the bottom one had a much better elongation; in other words, a much better ductility. The same phenomenon was found in cast iron. Harbach, at the annual conference of the Institute in 1935, gave a very interesting Paper on the co-relation of cast iron test results and he procured test bars from a vertical runner and found that the lower sample had a much better strength than the upper.

The Paper on silica sands was very interesting. He was impressed by one refractory which showed sintering temperatures in a reducing atmosphere to be higher than sintering temperatures in air. In most refractories the reverse was the case, due, amongst other factors, to the oxidation of iron. Was it a fact that silica sands sintered at a higher temperature under reducing conditions or had the columns in the illustration inadvertently been interchanged?

Monetary Incentive

MR. T. R. WALKER (honorary secretary), referring to apprentices, said he was employed by a firm which paid the fees of any juniors who attended technical classes in subjects relating to their employment. The firm also offered a shilling a week extra pay for every subject passed at the yearly examinations, up to 3s. The foundry classes at the Sheffield University had been running for several years, but none of their apprentices attended. Unless they were compelled, juniors would not attend the classes. He thought that the Institute had a legitimate sphere of action in persuading firms to induce their apprentices by some means or other to attend the classes, in the interests of the apprentices themselves and of the trade generally.

MR. E. J. BROWN, referring to the comments on his Paper "Detrimental Factors Affecting Steel Castings" made by Mr. Tucker, said that the very nature of the comment on the two tests obtained from the one bar indicated that the point of his Paper had been missed. He had no doubt that a similar variation in the value of two tests would be obtained with cast iron, and while it was admitted that such a variation existed, both industries had much to learn. No opinion was expressed in the Paper as to whether the difference was the outcome of inclusions or gas; it might be either, or both.

There was little difficulty in meeting a test with a single bar, but one had to resort to a few *tours de main*, which had been acquired.

For instance, a test bar cast in chill would invariably give better results than one cast in sand. In this case the often used expression "densener" was used in the metallurgical sense. The probable reason for the improvement was that with a reduction in the freezing range there was a corresponding reduction in the opportunity for gas generation.

Steel Test Bar Strengths

MR. WALKER said that in steel foundries the test piece from the bottom of the test block always gave the better results. It would be against the best interests of the foundry industry in general if buyers of steel castings had the right, which they had not, of taking samples for test from the castings themselves. In the case of ingots, whether large or small, the bottom half was the one which contained the most inclusions of silicates, and from that point of view it might be expected that the bottom half of the ingot would give worse results in mechanical tests than the top half. Actually, in the case of foundry test blocks the bottom half gave better results.

Considering the diagram of a test block shown in the Paper, he suggested that if it were redesigned so that the steel ran completely through the test block and out at the other side, still better results would be possible, as the danger of sand and other impurities being collected in the steel would be much reduced.

General Education Preferred

MR. S. LEETCH said he held different views from some people about the training of apprentices. A boy who had been in a foundry all day could hardly be expected to go to night-school to hear about foundry work. It would be better for him to go to night-school to get a general education. When he was about 19 he would begin to think about his future, and, equipped with a good general education, he could then specialise in foundry subjects. Mr. Leetch felt it was in the works where the real training must take place. At the foundry with which he was connected boys went into the foundry and did odd jobs, such as straightening lifters and making head bushes, until the opportunity came for those who showed an aptitude for the work to commence moulding.

The apprentices who were actually moulding were definitely under a foreman moulder, and no apprentice worked on repetition work on moulding machines. Their instruction was progressive, starting with small work, and as they showed progress they were given more responsible work. When they were 18 or 19 they were taken away from the apprentices' bay and put to work with moulders who were doing various classes of work. Even to-day, when the works were very busy, their young employees could be brought forward and by the time they were 30 he thought they could go anywhere.

Local Facilities

MR. WALKER said that in Sheffield there were three kinds of classes. It was intended that boys between the ages of 14 and 16 should go to evening continuation classes at the council schools. The courses there did not cover foundry practice specifically, but aimed at a general knowledge of applied science which was useful for any kind of industrial position. From 16 to 18 years of age they were expected to go to the Central Commercial College, where they received preparatory training in either engineering, metallurgy or foundry science. They were not supposed to enter the University classes until they were 18, and could then take special courses for engineering, metallurgy, foundry work or any other subject.

The BRANCH-PRESIDENT said he believed in training boys in the shop where they could get practical knowledge. If a boy were interested, he became a good moulder. On the other hand, if he wanted to advance to an executive position, he became interested from that point of view and continued his technical education. Most employees from 18 or 19 up to 40 went to the University classes with the idea of learning something about the technical aspects with a view to improving their position. A large percentage of the apprentices were content with being skilled moulders. Others had an urge to become foremen and eventually managers, and he thought it was those boys who took an interest in the classes.

MR. F. B. OLLERENSHAW asked how many firms in Sheffield adopted the same procedure as the firm where he was trained. He was a bound apprentice on seven years' indentures. How many firms were there in these days who adopted that method for their apprentices?

Indentured Apprenticeship Preferable

MR. J. B. ALLAN said it seemed to him that degeneration had occurred for 20 years or more. Formerly boys served an apprenticeship, generally in the works under some scheme such as Mr. Ollerenshaw had mentioned, but for their education generally attendance at evening classes, usually at the mechanics' institutes which existed in those days, was necessary. To his mind, a very large number of the older foremen, who, it was agreed by everyone, were excellent craftsmen, were brought up under that method. During the annual conference in Scotland this year he had the opportunity of talking to several foremen as to what happened about their apprentices. In two cases out of three any number of examples of apprentices were produced, working under some proper scheme, but in all cases attendance at evening classes had excellent results. Surely the bottom of the trouble was the individual himself.

Planning to Overcome Shortage

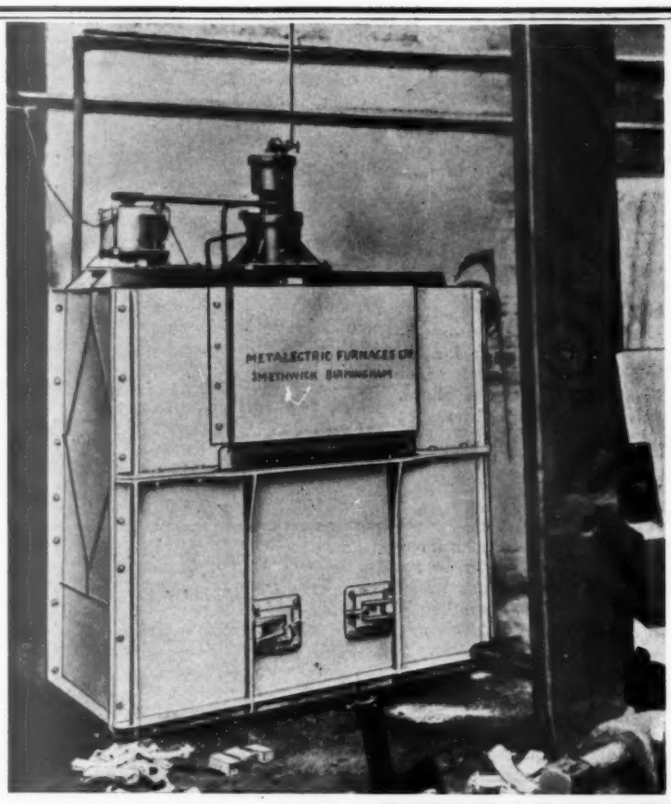
MR. M. BROWN said that skilled moulders would become more scarce. In large foundries in America half a dozen skilled moulders would not be found, and the problem had to be met by having much more supervision than obtained in England. The work was planned in an office by technical men who decided which way it was going to be done in all its details. The amount of detail was astonishing, but it was necessary because of the shortage of skilled men. The same position would eventually be reached in England.

The BRANCH-PRESIDENT asked if that view applied mostly to repetition foundries.

MR. BROWN said that it did not.

(*Concluded on page* 478.)

* These Papers were published in the November 19 issue of the FOUNDRY TRADE JOURNAL.



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Work of the Foundrymen's Technical Committee

TWO REPORTS DISCUSSED AT BIRMINGHAM

The work of Sub-Committees of the Technical Committee of the Institute of British Foundrymen on leaded gunmetals and dimensional tolerances for castings was discussed by the Birmingham, Coventry and West Midlands Branch of the Institute at its meeting last month. Mr. G. W. Brown (Branch-President) was in the chair.

MR. J. G. S. PRIMROSE summarised the recommendations of the Non-Ferrous Sub-Committee for two leaded gunmetals, and Mr. G. R. Shotton dealt with the report, "Dimensional Tolerances for Castings (with particular reference to Malleable Cast Iron)," prepared by the Sub-Committee on Malleable Cast Iron.

The CHAIRMAN said members would be aware that the Institute did a tremendous amount of valuable work of the kind under review, and there was a great deal of enthusiasm on the part of members of the Council, who spent much time trying to solve problems and to help foundrymen in their daily occupation.

With regard to the work of the Non-Ferrous Sub-Committee, MR. PRIMROSE was asked whether the same type of pyrometer was used for the tests in all cases. He was unable to give a definite answer, but said that for the most part a base-metal thermocouple was employed.

Attention was drawn to the fact that no reference was made in the recommendations to the question of fatigue resistance, and Mr. Primrose admitted that the matter had not yet been investigated by the Sub-Committee.

Heavily Leaded Alloys

MR. J. H. DOLPHIN said they were frequently recommended to use alloys containing much more lead than was included in the Sub-Committee's specifications, and such metals were fairly largely used on the Continent. Alloys, for example, containing as much as 20 per cent. lead were used, and he had lately examined some bearings with a content of 12 per cent. lead and 10 per cent. tin. The bearings, which had been in a Diesel engine for about fifteen years, had obviously given a good life, and when removed were in excellent condition. It appeared, therefore, that there was a call for some sort of specification for a high-leaded gunmetal. He would like to know whether Mr. Primrose had had any experience indicating that high-leaded gunmetals were satisfactory for heavy duty. He noticed that nickel was used in small quantities to ensure even distribution of the lead. Was the presence of nickel an advantage or a detriment, or was it used solely for the purpose he had mentioned?

MR. PRIMROSE, replying, said that if all the ranges of composition had been examined, the Paper would not have been presented yet. They had considered a higher-leaded specification, but there was not sufficient agreement about it to make a recommendation. Mr. Primrose assured Mr. J. H. Dolphin that this phase would certainly be studied in subsequent work. There was undoubtedly a demand for higher-leaded gunmetals in this country, but whether it could be said that there was a need for so high a percentage as 20 was doubtful. To get even 15 per cent. of lead evenly distributed in gunmetal was a difficult task, and nickel was added to assist them to obtain this result. Anything above 12 or 13 per cent. lead was liable to segregate and give large variations in composition between one point and another of the same bearing. The Sub-Committee had stated that up to 2 per cent. of nickel was permissible, but 1 per cent. was usually quite sufficient for lead up to 15 per cent. If 20 per cent. lead was included 1½ per cent. nickel might be required.

Thirty-Seven Specifications

MR. E. B. BAYLISS said it appeared that thirty-seven specifications had been examined, and he asked if it was the intention that these should be replaced by one or other of the two specifications given in Table III of the Report.

MR. PRIMROSE replied that the object of giving, in the compositions, the minimum for tin and the maximum for zinc and lead was to cover as many as possible of the thirty-seven alloys. Their aim was to arrive at a composition that would be sufficiently elastic while being different. They had no desire to preclude the use of any specially wanted alloy.

Tolerances

Discussing the second report on dimensional tolerances, MR. H. T. LANGLEY referred to an auto differential case on which Mr. Shotton had made some observations, and inquired whether it was etched and examined and whether the examination had revealed the presence of stresses.

MR. SHOTTON said he had no information about the internal structure of the castings. He was quite ready to believe that a particular case might show internal defects. He did not think, however, that they could assume that every casting showing a variation from the normal had an internal defect.

MR. E. W. WYNN expressed satisfaction that the Institute was conducting practical investigations which were bound to help the trade appreciably in the routine production of castings. To every foundryman, he said, the question of the amount of tolerance required was important, and there was a tremendous difference of opinion, even among engineers, as to how much should be allowed. Some of the tolerances seemed very generous; others were the reverse. Mr. Wynn added that he would welcome further information as to variations in the case of dry- and green-sand castings.

MR. SHOTTON called Mr. Wynn's attention to the fact that some figures were given in the Report. The castings to which they referred showed a contraction from the original pattern size when cast in green-sand moulds of $\frac{1}{8}$ in. to $\frac{3}{16}$ in. When cast in dry-sand moulds the contraction was $\frac{1}{64}$ in. to $\frac{3}{16}$ in. There was not quite so much contraction in the case of the dry-sand mould as the green-sand mould. At the same time, he did not think that could be taken as typical of any particular casting. A tolerance must be specified which the engineer would accept and which at the same time would be acceptable to the foundrymen. They could not cover every variable.

MR. J. HIRD asked how the rings referred to by Mr. Shotton were run, and if they were perfectly round.

MR. SHOTTON replied that they were run with a runner at one point on the outside flange, and there were two risers situated at equal angles of 120 deg. So far as the eccentricity was concerned, the castings were quite round, but there were minute variations. After annealing, a little distortion had occurred. They took a number of measurements across the diameter at various points and averaged them. Another series of tests was made on some patterns at a later date, when quite different contraction figures were obtained, probably due to a slight variation in casting temperature.

MR. W. J. MOLINEUX thought it must be admitted that a great many dimensional troubles in castings were due to the lax methods of the foundryman. When going from one foundry to another, he had noticed a very great divergence in the quality and accuracy of the tackle used, which was one of the causes of inaccurate results. Moulding boxes, for instance, could be a very serious cause of trouble, as well as the method of mounting patterns.

MR. SHOTTON said he supposed there were still small foundries which were run on rule of thumb lines, but the number was diminishing.

MR. J. HIRD suggested that a great deal of trouble might be obviated if the amount of taper was indicated, or if they were told when no taper could be allowed.

MR. SHOTTON said a fixed dimension was obviously open to a great deal of misinterpretation. If only the tolerances were mentioned, they would know which way to put the taper on. Without information the pattern might be tapered in exactly the reverse manner to that required. More detailed information of the engineer's requirements was wanted.

Cordial thanks were expressed to Mr. Primrose and Mr. Shotton, and to the Technical Sub-Committees, on the proposition of MR. MOLINEUX, seconded by MR. J. H. BRADSHAW.

Shortage of Skilled Labour

(*Concluded from page 476.*)

The BRANCH-PRESIDENT said that in England 80 per cent. of the foundries were jobbing foundries, and when a one-off job was required, all that trouble could not be taken. The Americans had a larger market for everything that was made.

MR. BROWN said it would not apply only to repetition foundries.

MR. O. M. BROWN suggested that boys who would not attend classes should be allowed to go in working hours. If employers got the boys interested in study and offered some prize or extra pay, they would create further apprentices.

MR. WALKER said the proper way of training apprentices was to make them attend classes during working hours as part of their work. By this means attendance at classes could be guaranteed. The classes could be made smaller and progress was likely to be ensured. No Sheffield firm, however, would admit that it could afford to train its apprentices in this way. He quite agreed that in America arrangements of this sort were much more common than in this country.

MR. BROWN said the time was coming when nobody could object if skilled labourers were not available in sufficient numbers.

MR. WALKER agreed, and said that skilled moulders and other foundry operatives were a dying population, and this was very much to be regretted.

Vote of Thanks

MR. ALLAN, in moving a vote of thanks to the Branch-President, said the members were indebted to him for promoting the competition and to the secretary for suggesting it. They had heard most interesting and instructive Papers.

MR. WHITEHOUSE seconded the resolution, which was carried.

The BRANCH-PRESIDENT, replying, said he very much appreciated their remarks. The success of the competition was his thanks for what he had done. He thanked the authors for taking the trouble to write the Papers and for contributing to a successful evening.

THE SPECIAL AREAS RECONSTRUCTION ASSOCIATION has made a loan of £10,000 for the establishment at Hartlepool of a new factory for the fabrication of steel products. It will be established on part of the premises of Irvines' Shipbuilding & Drydocks Company, on the south side of the shipyard. The capital of the new company, which will be known as Pailor, Lambhill & Company, will be £25,000. The £10,000 Special Areas Reconstruction Association loan is free of interest or repayment for two years.

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The Week's News in Brief

Trade Talk

THE U.S.S.R., it is reported, now produces daily an average of 83,000 tons of iron ore, 39,500 tons of pig-iron, and 48,800 tons of steel.

EXTENSIONS ARE TO BE MADE at the Durie Foundry, Leven, of Henry Balfour & Company, Limited, and at the Denny Ironworks of Cruikshank & Company, Limited.

BIRMINGHAM CATHEDRAL BELLS, which have been pronounced unsafe, are to be recast and rehung. There are ten bells, varying in size from 3 to 10 cwts.

ACCORDING TO A WRITER in the "Evening Standard," the Ford Motor Company's foundries use 200,000 gallons of soya bean oil as a core agglommerant per annum.

THE AILSA SHIPBUILDING COMPANY, LIMITED, of Troon and Ayr, have received an order from Robert Harper & Son, shipowners, of Glasgow, for a motor coasting vessel of about 500 tons deadweight.

THE EMPLOYEES OF Smith & Wellstood, Limited's Esse cooker department, Bonnybridge, held a dance last week, at which Mr. G. A. Ure, J.P., chairman of the company, and Mrs. Ure were present.

P. HENDERSON & COMPANY, Glasgow, have placed an order with William Denny & Bros., Limited, Dumbarton, for a cargo and passenger ship, with a deadweight carrying capacity of 9,000 tons. It will be propelled by single-reduction geared turbines.

THE FIRST International Electrodeposition Conference organised by the Electrodepositors' Technical Society will be held in London on March 3 and 4, 1937. Inquiries should be addressed to the Hon. Conference Secretary, Mr. H. Wynne-Williams, 12A, Raleigh House, Larkhall Estate, London, S.W.8.

THE MONKWEARMOUTH IRON AND STEEL WORKS, Sunderland, belonging to Samuel Tyzack & Company, Limited, have been bought by Thomas W. Ward, Limited, of Sheffield, for dismantling. The purchase does not include the site, buildings or railway sidings. The works, which have been closed down for some time, formerly produced 500 tons of steel and 150 tons of rivets a week.

THE IMPORT DUTIES ADVISORY COMMITTEE give notice of the application for an increase in the import duty of iron and steel tubes, cased with brass, copper or other non-ferrous metal. Any representations which interested parties may desire to make in regard to this application should be addressed in writing to the secretary, Import Duties Advisory Committee, Shell-Mex House, Strand, London, W.C.2, not later than December 31.

MR. J. G. PEARCE (director of the British Cast Iron Research Association) lectured on December 7 to the North-Eastern Branch of the Institution of Mechanical Engineers at Newcastle-upon-Tyne on "Modern Cast Irons in Engineering Practice." Among those present were Mr. James Smith (President of the National Ironfoundry Employers' Federation) and Mr. J. M. Weir, of the B.C.I.R.A. Council. A lengthy discussion followed.

THE BUREAU INTERNATIONAL DES APPLICATIONS DE L'ALUMINIUM, 23, rue de Balzac, Paris, 8, with the support of (*inter alia*) the British Aluminium Company, Limited, is organising a competition, open to inventors in all countries, with the object of evolving a process for the amelioration of the process known under the name of the M.B.V. process. The prize is 25,000 French francs (about £250). Entrance forms and full details can be had on application to the British Aluminium Company, Limited, Adelaide House, King William Street, London, E.C.4. The closing date for entering the competition is January 1, 1938.

Gun Metal

(*Concluded from page* 466.)

Interpretation of Fractured Specimens

The relative orientation of the interior dendritic structure of neighbouring crystals follows no definite plan; this is shown by microscopic observation of the specimen. Those crystals which are most favourably orientated will be stretched beyond the elastic limit first; they most probably are those whose principal axis of orientation coincides with the direction of the applied stress. The roughening or "crinkling" of the surface of the tensile bar shows that different crystals are affected unevenly. In other words, the mechanical properties of the individual crystals are not the same in all directions.[* 22] Thus a fine grained sound structure would be expected to exhibit a fine crinkle while a large grained porous bar, a very coarse crinkle.

Contracts Open

Ellington Colliery, December 19.—493 yds. of 2-in. cast-iron pipes, for the Morpeth Rural District Council. Mr. J. B. Annett, clerk, 15, Bridge Street.

London, W., December 31.—Tyres and rolled steel wheel centres; steel axles and forgings; iron bars and plates; steel sheets; steel bars and blooms; steel castings (wheel centres); steel castings (miscellaneous); chain; tubes and fittings (gas, steam, electric conduit, etc.); weldless steel tubes (steam and H.P. gas—cold finish); iron castings, pipes, etc.; galvanised sheets, for the Great Western Railway Company. The Stores Superintendent, Swindon.

Maenclochog, December 24.—12 miles of 6-in., 4-in. and 3-in. spun and other pipes with specials, for the Narberth Rural District Council. J. O. Parry & Lewis, Ammanford. (Fee £5 5s., returnable.)

Street, December 19.—543 yds. of 4-in. cast-iron mains, for the Glastonbury Gas Department. Mr. D. E. Garlick, manager, Gas Offices, 8, High Street, Glastonbury.

Wellington, January 12, 1937.—One 1-ton hand-operated overhead travelling crane, for the New Zealand Public Works Department. Tenders endorsed "Quotation for Travelling Crane" should be addressed to the secretary, Supplies and Tenders Committee, Public Works Department, Wellington, New Zealand.

Wellington, February 17, 1937.—Six air-compressor outfits, for the Post and Telegraphs Department. The Department of Overseas Trade. (Reference T.Y. 2,222.)

Worcester, December 31.—Iron castings and mild steel, for the County Council. Mr. B. C. Hammond, county surveyor, County Buildings, Worcester.

Company Reports

British Oxygen Company, Limited.—Dividend on the 6½ per cent. preference shares for the half-year to December 31.

Duffield Iron Corporation, Limited.—Development expenditure increased by £8,425 to £58,551 during year to September 30 last.

Greenwood & Batley, Limited.—Interim dividend on the preference shares for the year ending March 31, 1937, of 3½ per cent.

Cannon Iron Foundries, Limited.—Final dividend on the ordinary shares of 10 per cent., making 15 per cent. for the year ended September 30.

Herbert Morris, Limited.—Interim dividend on the ordinary shares, at the rate of 2½ per cent., actual, free of tax, on account of the year to July 31, 1937.

Marshall, Sons & Company (Successors), Limited.—First dividend of 5 per cent. per annum, less tax, for period ended September 30, 1936, calculated from date of allotment (April 4, 1936).

Company Meeting

Presiding at the annual meeting of Broom & Wade, Limited, last week, MR. HARRY S. BROOM (chairman) said that the company had had a very successful year. During the year the company acquired the whole of the capital of B.E.N. Patents, Limited, which manufactured similar equipment to that produced by Broom & Wade, Limited, but which had concentrated on a somewhat different market from that covered by the organisation of the parent company. B.E.N. Patents, Limited, also had a very satisfactory year's trading. The business in two comparatively new lines, rock drills and large compound compressors, continued to grow.

Personal

MR. W. F. WREN has joined the board of Allied Ironfounders, Limited.

MR. R. M. GRANT has been elected an additional director of Veritys, Limited, manufacturing electrical engineers, of Birmingham.

MR. G. A. LEITCH has been appointed chairman of the Cannon Iron Foundries, Limited, in place of the late Sir Francis Pepper.

COMMANDER SIR CHARLES CRAVEN has been elected chairman of the Industrial Welfare Society in succession to the late Lord Invernairn.

MR. MARTIN CORCORAN, who is retiring from his position with the Shelton Iron, Steel & Coal Company, Limited, received presentations from the mill office staff and finishing department recently.

MR. FRANK PARKINSON, chairman and joint managing director of Crompton Parkinson, Limited, manufacturing electrical engineers, an old student of the Yorkshire College, precursor of the present university, has offered to provide £200,000 for the erection of the central block in the main frontage of the Leeds University's new buildings.

Wills

HUNTER, SIR JOHN, chairman of Sir William Arrol & Company, Limited ...	£194,354
URE, ALLAN MCCLYMONT, director of Allan Ure & Company, Limited, of Glasgow	£30,552

Obituary

MR. G. T. COTTERILL, for over twenty years secretary to the Butterley Company, Limited, has died at the age of 69.

MR. SYDNEY PEARSON, a victim of the air crash in Surrey on December 9, was an employee of the Phosphor Bronze Company, Limited.

MR. FORBES DICK, who died recently at the age of 58, was managing director of the Brush Electrical Engineering Company, Limited, Loughborough.

MR. ARTHUR PARKER died recently at the age of 71. He was formerly for 44 years an engineer with Fairbairn, Lawson, Combe, Barbour, Limited, of Wellington Foundry, Leeds.

THE DEATH OCCURRED, on December 9, of Mr. Reuban M'Intosh, who was for 22 years employed in the former Gourlay's Foundry in Dock Street, Dundee. He was 68 years of age.

New Companies

(*From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.*)

Haybridge Steel Works, Limited, Wellington, Salop.—Capital, £10,000. Directors: A. W. Kieft, Mrs. L. M. Kieft, and C. W. Kieft.

Spannagel, Limited.—Capital, £5,000. Engineers, founders, etc. Directors: H. Spannagel, Alexanderstraat 10, The Hague; J. Le Boutillier, and A. J. Foster.

Stainless Steel Products (Birmingham), Limited, 5a, Temple Row, Birmingham.—Capital, £10,000. Directors: H. Radcliffe, J. Radcliffe, and A. H. Ripley.

Hattersley & Ridge, Limited.—Capital, £1,500. Steel and tool manufacturers, etc. Directors: A. Hattersley, 22, Kingsley Park Avenue, Sheffield; W. Ridge, and Mrs. C. M. Hattersley.

Forthcoming Events

Institute of British Foundrymen

DECEMBER 19.

Lincolnshire Section:—"Moulding Pumps without Patterns," Paper by F. F. Mather, at the Technical College, Monks Road, Lincoln, at 7 p.m.

Newcastle-upon-Tyne Branch:—Joint meeting with Institute of Metals and Coke Oven Managers' Association: "Refractories for Foundry Purposes," Paper by P. B. Robinson, M.Met., at the Neville Hall, Westgate Road, Newcastle-upon-Tyne, at 6.15 p.m.

DECEMBER 21.

Falkirk Section:—"Developments in the Production of Ingot Mould Castings," Paper by R. Ballantine, at the Temperance Café, Lint Riggs, Falkirk, at 7.15 p.m.

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NON-FERROUS FOUNDERS

used in the manufacture of—

Electric Cookers. Gas Cookers. Motor Transport Vehicles. Aeroplanes. Internal Combustion Engines. Cast Iron Bath Fittings. Brass Water Service Fittings. Sluice Valves. Gas Valves. Rain Water Castings. Textile Machinery. Lawn Mowers. Ship Building, etc., and General Engineering Castings.

FOUNDRY ENGINEERS LIMITED

HALIFAX ——— YORKS.

Telephone: Halifax 61459. Telegrams: "FEL," Halifax.

Raw Material Markets

The demand for iron and steel continues to increase, but little fresh business can be accepted owing to the shortage of supplies. Unless present outputs can be considerably increased the outlook is not favourable. Deliveries are frequently in arrears, and work at the consuming plants is likely to become inconvenienced. Prices of hematite are, as yet, unchanged, but advances are likely to be made in the near future.

Pig-Iron

MIDDLESBROUGH.—Business in the foundry pig-iron market is on a good scale following the makers' intimation that they will accept orders for delivery up to the end of June. Supplies, however, are still short, and have to be carefully distributed. No. 3 Cleveland G.M.B. is quoted at 81s. per ton, delivered in the Middlesbrough district, 83s. elsewhere on the North-East Coast, 84s. in Falkirk, and 87s. in Glasgow. For No. 1 quality a premium of 2s. 6d. is charged, while No. 4 foundry and No. 4 forge are at 1s. per ton less than the price of No. 3 grade.

Quiet conditions, as far as the transaction of new business is concerned, are prevailing in the hematite market, but this is welcomed by producers as a chance for them to catch up on some of their delivery arrears. As a result of the recent increase in foundry iron prices, when the 5s. rebate is taken into account, the net figure of East Coast hematite mixed numbers is less than that of No. 3 foundry. Undoubtedly this anomalous position will be remedied, and it is thought likely that an advance of 10s. per ton will shortly be brought into operation.

LANCASHIRE.—There continues to be a satisfactory volume of business transacted in this area, and the recent increase in prices has not affected the demand. While many users are covered over several months, there are others who buy only as the occasion demands. Deliveries have been well maintained. Offers of Staffordshire and Derbyshire No. 3 foundry iron for delivery in the Lancashire price zone are on the basis of 89s. per ton, with Northamptonshire at 87s. 6d., and Derbyshire forge iron at from 84s. to 86s. In view of the inability of consumers to obtain supplies, quotations of hematite are purely nominal.

MIDLANDS.—It is still possible to obtain supplies of Derbyshire iron for delivery up to the end of June, but nearly all of the Northamptonshire producers have disposed of their outputs over this period, which is as far as they are willing to negotiate at the present time. For delivery to Birmingham and Black Country stations, Derbyshire, Lincolnshire and North Staffordshire No. 3 are quoted at 86s., and Northamptonshire No. 3 at 83s. 6d., subject to a small sliding-scale rebate to large consumers, with an additional 11d. per ton if delivery into works is required. An active inquiry exists for forge pig-iron, but here, again, supplies are difficult to procure, owing to the severe shortage. Special-grade irons are heavily inquired for, particularly by the motor and general engineering trades. The makers of small tools are also needing large supplies. Medium-phosphorus iron is quoted at 90s. to 95s., low-phosphorus at 95s. to 105s., Scottish No. 3 at 106s., and refined iron, on which there is still no control, at £6 5s. to £7 10s. per ton, delivered the Midlands. Owing to the absence of supplies, quotations for hematite are only nominal. West Coast mixed numbers are at £4 17s., East Coast No. 3 at £4 16s., and Welsh mixed numbers at £4 15s. 6d., delivered the Midlands. These prices are at present subject to a premium, but it is expected that an increase will be made in the near future. Meanwhile, producers are having considerable difficulty with the execution of deliveries, and in many cases these have fallen behind schedule.

SCOTLAND.—Following the recent advance in prices, pig-iron makers have intimated their willingness to permit users to purchase supplies for delivery up to June, 1937. No. 3 Scottish foundry is quoted at 88s. per ton at furnaces. Some substantial tonnages have been contracted for over this period. The shortage of Cleveland iron remains acute, and inquiries, which are numerous, are having to be refused. No. 3 Cleveland iron is quoted at 84s. f.o.t. Falkirk and 87s. f.o.t. Glasgow. Northamptonshire iron is quoted at 1s. 3d. below the foregoing figures. Very active conditions continue to be experienced by the light-castings makers and steelmakers. Prices of steel-making irons are 85s. 6d., less 5s. rebate, for mixed numbers of East Coast, West Coast and Scottish hematite. and 75s., less 5s. rebate, for British and Indian basic, all f.o.t. steelworks.

Coke

Firm conditions continue to prevail on the foundry-coke market. The demand is heavy, although most consumers have covered their requirements over a considerable period. For delivery in Birmingham and district, best Durham coke is quoted at 42s. 6d. to 45s., with Welsh coke at 41s. 6d. to 54s. per ton.

Steel

Supplies of steel remain difficult to procure, and as the demand is increasing, there is much inconvenience caused to consumers. Orders for semi-finished steel will not be accepted for early delivery, as producers have their outputs fully disposed of over a considerable period. Deliveries of finished steel have fallen still further into arrears, and the outlook is by no means a happy one for producers. Owing to the insistent home demand export inquiries are having to be refused, or, at the least, held over for a considerable time.

Scrap

There is no change to report in prices on the Cleveland scrap market, but the demand is very active and some advances are likely to be made in the near future. Heavy steel scrap is quoted at 60s. per ton, while a good inquiry is received for machinery metal at a minimum of 67s. 6d. Heavy cast-iron scrap is well taken up by the foundries at 65s., with light metal at 53s. to 53s. 6d. All descriptions of scrap in the Midlands are moving freely. Heavy steel in furnace sizes is at 55s., with mixed heavy iron and steel at 53s. 6d. Heavy machinery in cupola sizes is at 72s. 6d., good heavy at 67s. 6d., and clean light at 55s. Short, heavy, steel, suitable for use in the foundries, is at 67s. 6d. per ton, delivered works. A firm market is also experienced in Scotland, and large tonnages are changing hands. Heavy steel scrap in furnace sizes is at 57s. 6d., with heavy basic, or heavy iron and steel scrap mixed, 52s. 6d. Heavy machinery cast-iron scrap, in pieces not exceeding 1 cwt., is quoted at 72s. 6d. to 74s., with ordinary cast-iron scrap, to the same specification, at 68s. 6d. per ton, delivered f.o.t. consumers' works.

Metals

Copper.—Active conditions have prevailed in this market during the past week, and substantial tonnages have been involved in recent transactions. In view of the general industrial uncertainty owing to the Constitutional crisis this had not been expected. Considerable activity is also reported from the United States, where working-up plants are operating at about 95 per cent. of capacity. The price has been raised to 11 cents per lb. On the Continent, the position in France is not too clear at the present time, for, although there are definite signs of a revival in industry, aided by the devaluation of the franc, the introduction of the 40-hr. week and higher wages are not helpful in existing circumstances.

Daily market prices :—

Cash.—Thursday, £44 7s. 6d. to £44 8s. 9d.; Friday, £44 12s. 6d. to £44 13s. 9d.; Monday, £45 1s. 3d. to £45 3s. 9d.; Tuesday, £45 18s. 9d. to £46.

Three Months.—Thursday, £44 13s. 9d. to £44 15s.; Friday, £44 18s. 9d. to £45; Monday, £45 8s. 9d. to £45 10s.; Tuesday, £46 6s. 3d. to £46 7s. 6d.

Tin.—The International Tin Committee, at their meeting in London on Friday, decided to reduce the tin quota from 105 per cent. to 100 per cent. for the first quarter of 1937. In an official statement issued after the meeting it is said that if tin control is renewed the quota for this period will be fixed by the new Committee, which will possess plenipotentiary powers to fix quotas. A final draft of the scheme for the renewal of control for a period of five years from January 1, 1937, was approved by the Committee. It is further announced that if tin control be renewed the new International Tin Committee will meet in Brussels on January 5, 1937. No surprise was occasioned to the market at the quota reduction, and conditions generally have been firm, with prices showing a rising tendency.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £232 5s. to £232 10s.; Friday, £234 5s. to £234 10s.; Monday, £230 10s. to £230 15s.; Tuesday, £233 10s. to £233 15s.

Three Months.—Thursday, £232 5s. to £232 10s.; Friday, £234 5s. to £234 10s.; Monday, £230 10s. to £230 15s.; Tuesday, £233 10s. to £233 15s.

Spelter.—There is little of interest to report in this market, which continues along an uncertain course. The Constitutional question has had anything but a favourable influence on the market, and a forecast of the future trend cannot be undertaken with any degree of accuracy. A new organisation, sponsored by the Zinc Institute and to be known as the Galvanisers' Committee, has been established to ally technical groups in the zinc and steel industries. According to the American Bureau of Metal Statistics the world output of spelter in October was 142,497 short tons, as compared with 134,083 tons in September.

Official quotations were as follow :—

Ordinary.—Thursday, £17; Friday, £17 10s.; Monday, £17 15s.; Tuesday, £18 11s. 3d.

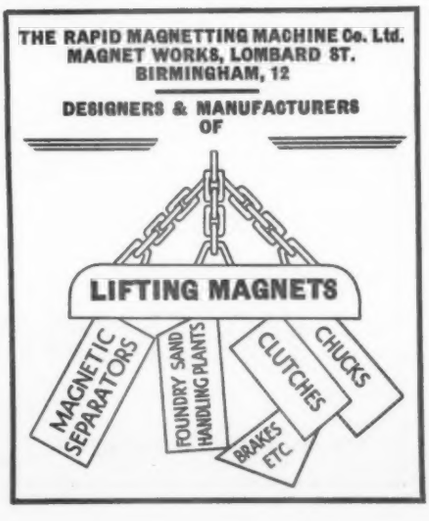
Lead.—A continuance of satisfactory business has again been reported, and prospects are good. Cable, pipe, sheet and battery makers all have excellent requirements. Prices are high, and last week reached the peak since 1929. It is reported that the Japanese import duty on lead is to be withdrawn. Japan has recently been in the market for substantial tonnages. The Metallgesellschaft states that the world's output from lead smelters during October was 122,501 metric tons, as against 111,871 tons in September. Any Spanish production that might have been obtained is not included in the foregoing figures.

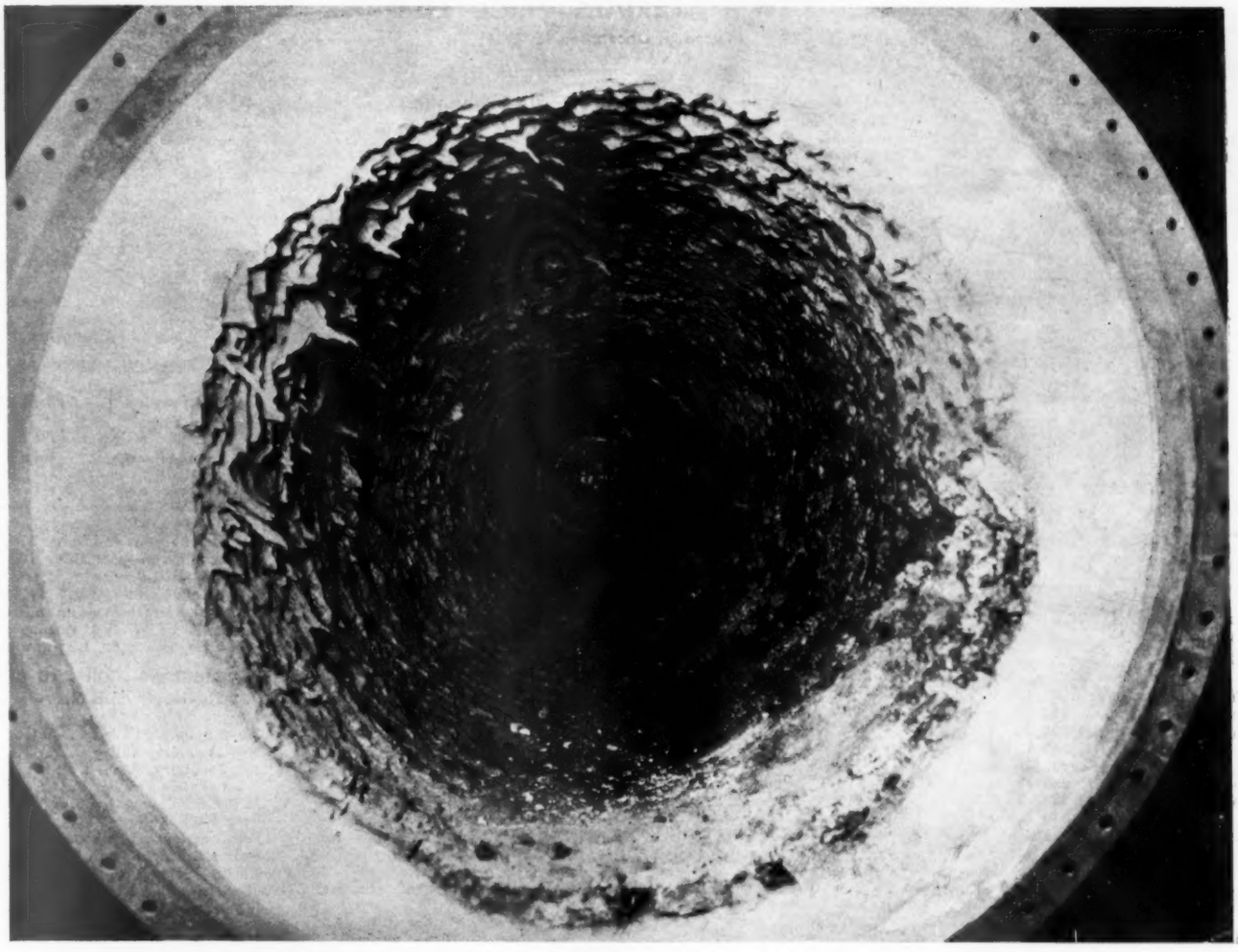
Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £24 3s. 9d.; Friday, £24 12s. 6d.; Monday, £25 15s.; Tuesday, £26 1s. 3d.

Notes from the Branches

East Anglian Section.—Mr. L. Tibbenham presided at a well attended meeting held at the Central Library, Ipswich, on December 3, when MR. A. J. RICHMAN delivered a Paper on "Some Simple Founding Principles." During the course of an interesting Paper the lecturer dealt with the effects of heat conductivity, speed of pouring and composition of metal upon the liquid shrinkage of cast iron. "Hot spots" and the effect of ferro-static pressure in overcoming shrinkage cavities were considered, as were risers, runners and pouring speed. Some extremely interesting results obtained from the use of the two-cupola process wherein mixtures of high and low-silicon iron are made in various proportions when in the molten state, were also given. A good discussion ensued in which Mr. Geo. Hall, Mr. W. L. Hardy, Mr. C. H. Kain and Mr. H. H. Shepherd took part.





950 tons of metal melted—

The above photograph shows the condition of an 04 grade Albino lining in a 5-ton Brackelsberg furnace after 255 heats. You will observe the lining has worn back evenly and it is still approximately 8" in thickness. The 04 grade is specially produced for rotary furnaces, but there are other grades for lining cupolas, converters and ladles. This photograph is reproduced by courtesy of James Howden and Company (Land) Ltd.

ALBINO

ROTARY FURNACE LINING MATERIAL

Please send enquiries to the nearest Sales Office:

GENERAL REFRACTORIES LIMITED,

Genefax House, Sheffield, 10

Telephone: Sheffield 31113 (6 lines) Telegrams: "Genefax, Sheffield"

LONDON OFFICE: Russell House, Adelphi, W.C.2 Telephone: Temple Bar 7361 Telegrams: "Genefax, Rand-London"

SCOTTISH OFFICE: 156, St. Vincent Street, Glasgow Telephone: 5250 Telegrams: "Genefax, Glasgow"

MANCHESTER OFFICE: 9, Albert Square, Manchester, 2 Telephone: Blackfriars 6130 Telegrams: "Genefax, Manchester"

SOUTH WALES OFFICE: 11, Wind Street, Swansea Telephone: 3680 Telegrams: "Genefax, Swansea"

MIDDLESBROUGH OFFICE: 20, Marton Road, Middlesbrough

MANUFACTURERS OF HEAT RESISTING AND HEAT INSULATING MATERIALS OF EVERY DESCRIPTION.

RAW MATERIALS—PRICE LIST

(Tuesday, December 15, 1936)

COPPER

	£ s. d.
Standard cash	45 18 9
Three months	46 6 3
Electrolytic	50 5 0
Tough	48 0 0
Best selected	48 10 0
Sheets	77 0 0
India	58 5 0
Wire bars	49 15 0
Ingot bars	49 15 0
H.C. wire rods	53 5 0
Off. av. cash, Nov.	43 19 5 1/16
Do., 3 mths., Nov.	44 6 7 9/16
Do., Sttlmnt., Nov.	43 19 7 5/16
Do., Electro, Nov.	48 14 6 15/16
Do., B.S., Nov.	48 8 1 1/2
Do., wire bars, Nov.	48 19 9 1/4
Solid drawn tubes	11 1/2d.
Brazed tubes	11 1/2d.
Wire	7 1/2d.

BRASS

Solid drawn tubes	10 1/2d.
Brazed tubes	12 1/2d.
Rods, drawn	9 1/2d.
Rods, extd. or rlld.	5 1/2d.
Sheets to 10 w.g.	8 1/2d.
Wire	8 1/2d.
Rolled metal	8 1/2d.
Yellow metal rods	5 1/2d.

TIN

	£ s. d.
Standard cash	233 10 0
Three months	233 10 0
English	233 10 0
Bars	235 10 0
Straits	235 10 0
Australian	233 10 0
Eastern	235 7 6
Banca	235 10 0
Off. av. cash, Nov.	231 0 11 7/8
Do., 3 mths., Nov.	229 5 10
Do., Sttlmt., Nov.	231 0 11 7/8

SPELTER

	£ s. d.
Ordinary	18 11 3
Remelted	15 10 0
Hard	14 10 0
Electro 99.9	20 12 6
English	18 10 0
India	15 5 0
Zinc dust	20 10 0
Zinc ashes	4 15 0
Off. aver., Nov.	16 8 6 1/2
Aver. spot, Nov.	16 6 0 5/8

LEAD

	£ s. d.
Soft foreign ppt.	26 1 3
Empire	26 10 0
English	28 0 0
Off. aver., Nov.	21 14 2
Aver. spot, Nov.	21 14 5 1/2

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£ s. d. to £ s. d.
Zinc sheets, English	28 5 0 to 28 15 0
Do., V.M. ex-whse.	28 5 0 to 28 15 0
Rods	29 15 0

ANTIMONY

	£ s. d. to £ s. d.
English	67 10 0 to 68 10 0
Chinese, ex-whse.	57 10 0
Crude, c.i.f.	28 10 0

QUICKSILVER

Quicksilver	14 2 6

FERRO-ALLOYS AND STEEL-MAKING METALS

	£ s. d. to £ s. d.
Ferro-silicon—	
25%	8 17 6
45/50%	11 0 0 to 12 5 0
75%	16 2 6 to 17 7 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 to £22
Ferro-tungsten—	
80/85%	3/1 1/2 lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	33 0 0
4/6% car.	21 10 0
6/8% car.	21 0 0
8/10% car.	21 0 0
Ferro-chrome—	
Max. 2% car.	33 10 0
Max. 1% car.	36 5 0
Max. 0.5% car.	37 5 0
70% carbon-free	9 1/2d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	7/3 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese—	
76/80% loose	£11 15 0 to 12 5 0
76/80% packed	£12 15 0 to 13 5 0
76/80% export	£10 15 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under 1/2 in. to 1/4 in.	3d. lb.
Do., under 1/4 in. to 7/16 in.	1/– lb.
Flats, 1/2 in. × 1/4 in. to under 1 in. × 1/8 in.	3d. lb.
Do., under 1/4 in. × 1/4 in.	1/– lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£ s. d.	£ s. d.
South Wales—		
Heavy steel		3 4 0
Mixed iron and steel	3 0 0	to 3 1 0
Heavy cast iron	2 18 0	to 3 0 0
Good machinery	3 2 0	to 3 4 0
Cleveland—		
Heavy steel		3 0 0
Steel turnings		2 5 0
Heavy cast iron		3 5 0
Heavy machinery		3 7 6
Midlands—		
Light cast-iron scrap		2 15 0
Heavy wrought iron	3 5 0	to 3 7 6
Steel turnings		2 0 0
Scotland—		
Heavy steel		2 17 6
Ordinary cast iron		3 8 6
Engineers' turnings		2 2 6
Cast-iron borings		1 18 0
Wrot-iron piling		3 10 0
Heavy machinery	3 12 6	to 3 14 0

London—Merchants' buying prices, delivered yard.

	£ s. d.
Copper (clean)	37 0 0
Brass	22 0 0
Lead (less usual draft)	20 15 0
Tea lead	16 10 0
Zinc	9 10 0
New aluminium cuttings	74 0 0
Brazier copper	34 0 0
Gunmetal	34 0 0
Hollow pewter	165 0 0
Shaped black pewter	122 0 0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	83/6
„ No. 3	81/–
„ No. 4	80/–
Forge No. 4	80/–
Hematite No. 1	85/6*
Hematite M/Nos.	85/–*
N.W. Coast—	
Hem. M/Nos. d/d Glas.	85/6*
„ d/d Birm.	97/–*
Malleable iron d/d Birm.	125/–
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	83/–
„ No. 3 fdry.	86/–
Northants forge	80/6
„ fdry. No. 3	83/6
„ fdry. No. 1	86/6
Derbyshire forge	83/–
„ fdry. No. 3	86/–
„ fdry. No. 1	89/–
Scotland—	
Foundry, No. 1, f.o.t.	90/6
„ No. 3, f.o.t.	88/–
Cleveland No. 3, Glasgow	87/–
„ „ Falkirk	84/–
Scottish hem. M/Nos. d/d	85/6*
Sheffield (d/d district)—	
Derby forge	80/6
„ fdry. No. 3	83/6
Lincs forge	80/6
„ fdry. No. 3	83/6
W.C. hematite	91/–*
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	89/–
Staffs fdry. No. 3	89/–
Northants fdry. No. 3	87/6
Cleveland fdry. No. 3	89/–
Glengarnock, No. 3	102/6
Clyde, No. 3	102/6
Monkland, No. 3	102/6
Summerlee, No. 3	102/6
Eglinton, No. 3	102/6
Gartsherrie, No. 3	102/6
Shotts, No. 3	102/6

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)		10 10 0
Nut and bolt iron	8 17 6	to 9 7 6
Hoops		11 7 6 and up.
Marked bars (Staffs) f.o.t.		13 0 0
Gas strip		11 7 6 and up.
Bolts and nuts, 1/2 in. × 4 in.		16 0 0 and up.
Steel—		
Plates, ship, etc.	9 7 6	to 9 10 0
Boiler plts.	9 17 6	to 10 0 0
Chequer plts.		11 0 0
Angles		9 0 0
Tees		10 0 0
Joists		9 7 6
Rounds and squares, 3 in. to 5 1/2 in.		10 0 0
Rounds under 3 in. to 1/4 in. (Untested)		9 7 0
Flats—8 in. wide and over		9 5 0
„ under 8 in. and over 5 in.		9 10 0
Rails, heavy	8 5 0	to 8 10 0
Fishplates		12 10 0
Hoops (Staffs)		10 2 0
Black sheets, 24g. (4-t. lots)		12 0 0
Galv. cor. shts. („)		14 0 0
Galv. flat shts. („)		14 10 0
Galv. fencing wire, 8g. plain		15 0 0
Billets, soft		6 2 6
Billets, hard	7 7 6	to 8 7 6
Sheet bars	6 0 0	to 6 10 0
Tin bars	6 0 0	to 6 10 0

PHOSPHOR BRONZE

	Per lb. basis
Strip	11d
Sheet to 10 w.g.	12d
Wire	13 1/2d.
Rods	12 3/4d.
Tubes	14 3/4d.
Castings	12 1/2d.

Delivery 3cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1 1/2 to 1/7 1/2
To 15 in. wide	1/1 1/2 to 1/7 1/2
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2 1/2 to 1/8 1/2
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3 1/2
Ingots rolled to spoon size	10d. to 1/6 1/2
Wire round—	
to 10g.	1/4 1/2 to 1/11 1/2

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3 1/2 upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	22.31
No. 2 foundry, Valley	20.50
No. 2 foundry, Birm.	16.88
Basic, Valley	20.00
Malleable, Valley	20.50
Grey forge, Valley	20.00
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	36.37 1/2
Billets	32.00
Sheet bars	32.00
Wire rods	40.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	2.05
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.80
Steel hoops	1.95
Sheets, black, No. 24	2.60
Sheets, galv., No. 24	3.20
Wire nails	2.05
Plain wire	2.50
Barbed wire, galv.	2.55
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	30/– to 32/6
„ furnace	24/6 to 25/–
Durham foundry	24/6
„ furnace	21/6
Scotland, foundry	30/–
„ furnace	25/– to 26/–

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	18/9 to 19/3
„	28×20 „	37/6 to 38/–
„	20×10 „	27/– to 27/6
„	18 1/2×14 „	19/6 to 19/9
C.W.	20×14 „	16/– to 16/6
„	28×20 „	34/6 to 35/–
„	20×10 „	23/3 to 23/6
„	18 1/2×14 „	16/6

SWEDISH CHARCOAL IRON & STEEL

	£ s. d. to £ s. d.
Pig-iron	£6 0 0 to £7 0 0
Bars-hammered, basis	£16 0 0 to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0 to £16 0 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£25 0 0 to £28 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£	s.	d.		
Dec.	10 ..	44	7	6	No change	
,,	11 ..	44	12	6	inc.	5/–
,,	14 ..	45	1	3	,,	8/9
,,	15 ..	45	18	9	,,	17/6

Standard Tin (cash)

		£	s.	d.		
Dec.	10 ..	232	5	0	inc.	15/–
,,	11 ..	234	5	0	,,	40/–
,,	14 ..	230	10	0	dec.	75/–
,,	15 ..	233	10	0	inc.	60/–

Spelter (ordinary)

		£	s.	d.		
Dec.	10 ..	17	0	0	No change	
,,	11 ..	17	10	0	inc.	10/–
,,	14 ..	17	15	0	,,	5/–
,,	15 ..	18	11	3	,,	16/3

Lead (soft foreign, prompt)

		£	s.	d.		
Dec.	10 ..	24	3	9	inc.	2/6
,,	11 ..	24	12	6	,,	8/9
,,	14 ..	25	15	0	,,	22/6
,,	15 ..	26	1	3	,,	6/3

Electrolytic Copper

		£	s.	d.		
Dec.	10 ..	48	15	0	No change	
,,	11 ..	49	0	0	inc.	5/–
,,	14 ..	49	0	0	No change	
,,	15 ..	50	5	0	inc.	25/–

Tin (English ingots)

		£	s.	d.		
Dec.	10 ..	232	5	0	inc.	15/–
,,	11 ..	234	10	0	,,	45/–
,,	14 ..	230	10	0	dec.	80/–
,,	15 ..	233	10	0	inc.	60/–

Spelter (Electro, 99.9 per cent.)

		£	s.	d.		
Dec.	10 ..	19	0	0	dec.	1/3
,,	11 ..	19	11	3	inc.	11/3
,,	14 ..	19	16	3	,,	5/–
,,	15 ..	20	12	6	,,	16/3

Lead (English)

		£	s.	d.		
Dec.	10 ..	26	5	0	inc.	5/–
,,	11 ..	26	10	0	,,	5/–
,,	14 ..	27	15	0	,,	25/–
,,	15 ..	28	0	0	,,	5/–

Imports and Exports of Pig-iron, Castings, etc., in November and the Eleven Months 1936, compared with November and the Eleven Months 1935.

	November.		Eleven months.		November.		Eleven months.	
	1935.	1936.	1935.	1936.	1935.	1936.	1935.	1936.
	Tons.	Tons.	Tons.	Tons.	£	£	£	£
Imports.								
Pig-iron—from British India	2,696	17,832	60,541	123,808	8,121	58,217	180,858	394,466
,, Foreign Countries	1,793	11,136	14,804	101,166	10,067	40,922	86,413	351,219
Total	4,459	28,968	75,345	224,974	18,188	99,139	267,271	745,685
Castings and forgings	373	246	2,986	6,027	10,091	7,846	81,584	209,125
Cast pipes and fittings	101	199	1,546	1,491	3,194	7,184	40,094	49,711
Stoves and grates, etc.	46	114	1,040	766	4,379	8,358	86,067	68,450
Baths	464	771	6,260	7,556	12,723	17,564	166,438	182,466
Hollow-ware, all kinds	235	546	2,390	3,564	16,361	20,232	158,369	182,402
Exports.								
Pig-iron, forge and foundries	10,060	4,693	88,650	52,052	33,647	17,877	306,483	200,901
,, acid	3,061	1,836	45,508	37,651	10,175	7,194	147,430	138,553
,, basic	—	271	829	423	—	798	2,650	1,608
Total	13,121	6,800	134,987	90,126	43,822	25,869	456,563	341,062
Castings and forgings	330	385	3,931	3,708	11,211	13,824	150,130	138,983
Cast pipes and fittings up to 6 in. diameter	5,617	5,419	54,627	52,847	59,027	57,694	604,650	590,410
,, ,, ,, ,, over 6 in.	3,446	3,599	31,537	36,000	29,762	29,574	257,751	295,318
Stoves, grates, etc.	994	976	8,309	9,665	52,393	48,471	423,440	486,244
Sanitary cisterns	313	238	2,877	2,753	9,191	7,786	84,654	85,377
Bedsteads, including tubes therefor	473	428	4,204	4,564	18,100	15,147	154,510	107,044
Cast hollow-ware	443	530	3,965	5,117	14,275	18,261	145,764	183,704

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PATENT

THE proprietor of British Patent No. 399,475, dated March 31, 1932 (Convention Date May 4, 1931), for "Improvements relating to the reduction of ore," is desirous of entering into arrangements by way of a licence or otherwise on reasonable terms for the purpose of exploiting the above patent and ensuring its practical working in Great Britain. Inquiries to MR. B. SINGER, Chrysler Building, New York City, N.Y., U.S.A.

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TABOR PNEUMATIC MOULDING MACHINES for sale. For price and particulars apply: WILCOX & Co. (B'HAM), LTD., 65-71, Barr Street, Birmingham, 19.

MACHINERY—*Continued*

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